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ELECTRIC RAILWAY TRACTION

A Supplement illustrating and describing developments in Electric Railway Traction is presented with each copy of this week's issue.

Successful Southern Railway Rating Appeal

THE result of the sixteen days' hearing before the Railway and Canal Commission of cross appeals by the Southern Railway Company and the local authorities concerned against the assessment at £2,180,000 of the company's railway hereditaments by the Railway Assessment Authority was a judgment on Wednesday substantially in favour of the railway company. Instead of £2,180,000 the net annual value is found to be £1,077,131, which, subject to what the House of Lords may decide, will prevail for each of the five years from April 1, 1931-1936, and involve considerable re-payments to the company. Mr. Justice Mackinnon in his judgment was careful to point out that the decision was based on the facts of this particular case and was not to be regarded as a formula for others. As the judge explained, the old principle that the rent which a hypothetical tenant might be expected to pay was the net annual value did not cease to apply under the Act of 1930. To arrive at this value there had to be ascertained the tenant's capital, the interest to be allowed on that capital, and the average annual net receipts of the undertaking. The net receipts had been agreed at £5,408,000. Tenant's capital, in the shape of rolling stock, &c., was unanimously found to be £27,610,690, and the interest at 15 per cent. on that capital was £4,141,603. Adding £189,266 as the tenant's share of receipts earned without the use of his rolling stock, made a total of £4,330,869 to be deducted from the net receipts so as to arrive at the net annual value.

* * * *

Train Talks

Believing that "people are more keenly interested in railroads than ever before," the Pennsylvania Railroad recently began the publication of a series of leaflets entitled *Train Talks* in which to place before its patrons the railway viewpoint on matters of mutual interest and concern. The present time has been selected in that electrification, streamlining, air-conditioning, high speeds, and other developments in U.S.A. railroading are attracting nation-wide interest and centring the attention of that country upon the vital importance of rail service. It will be recalled that the London "Underground" adopted a similar course in pre-war years in producing *T.O.T.* for free distribution at stations at a time when tube developments and rail and road co-ordination were novelties to the London travelling public. The *Train Talks* leaflets are being distributed in the passenger coaches and Pullman cars of Pennsylvania Railroad trains throughout the system, as well as at ticket offices and information bureaux. They appear at irregular intervals and each issue is devoted to a single topic or to related topics. A rail system of the size of the Pennsylvania—some 2,500 track miles in thirteen states and the District of Columbia—should provide ample scope in its activities to fill pamphlets for an indefinite period. Incidentally, it has almost a quarter of a million stockholders, nearly half of whom are women, and some 116,000 employees.

* * * *

The Week's Traffics

Apart from small increases in passenger train takings by the L.M.S., Great Western and Southern Railways, a substantial increase in coal receipts on the L.M.S., and an advance of £5,000 in merchandise takings on the Great Western, the traffic returns of the four group companies for the past week are disappointing. During the first five weeks of 1935 passenger train earnings of the four companies together have amounted to £4,961,000, an increase of £133,000 or 2·75 per cent. For the corresponding five weeks of 1934 the joint increase of the four companies in merchandise takings was £692,500 or 16·84 per cent.

	5th Week				Year to date.
	Pass., &c.	Goods, &c.	Coal, &c.	Total.	Inc. or dec.
	£	£	£	£	£ %
L.M.S R. ..	+ 1,000	− 8,000	+ 12,000	− 5,000	− 3,000 − 0·06
L.N.E.R. ..	—	− 15,000	− 2,000	− 17,000	− 26,000 − 0·65
G.W.R. ..	+ 5,000	+ 5,000	− 3,000	+ 7,000	+ 33,000 + 1·52
S.R. ..	+ 5,000	− 5,000	− 2,000	− 2,000	+ 2,000 + 0·12

London Transport receipts for 31 weeks amount to £16,489,100, an increase of £327,200. The Great Northern Railway (Ireland) has an increase of £100 for the week, making an advance of £4,500 for the year to date. Great Southern Railways receipts for the five weeks show an increase of £51,256.

* * * *

Brussels-Tervueren Railway

In view of the approaching inauguration of electrical working between Brussels and Antwerp it may be of interest to recall that the only standard-gauge railway in Belgium at present electrically operated is the Brussels-Tervueren line of 9 miles. As described in THE RAILWAY GAZETTE of July 14, 1933, the line is worked by a private company under a concession from the Belgian National Railways. Hitherto only the passenger traffic has been worked electrically, by multiple-unit trains consisting of one motor vehicle and one trailer, and goods traffic has

been hauled by steam locomotives of the Belgian National Railways, but an electric locomotive has been ordered for this purpose. The latest results so far published are those for the year 1933 when 1,186,769 passengers were carried, an increase of 11·6 per cent. upon the figures for 1932. Goods traffic, on the contrary, continued to feel the effects of the business depression. At present the line is single except at the stations and for the 1·2 miles between Auderghem and Woluwe-Village, but it has been decided to double it on two more sections for a total distance of about 2½ miles. During 1933 it was decided to instal home signals for the protection of stations and to centralise the working of the points in lever frames in place of the ground levers previously used. Results in 1933 were insufficient by fr. 20,290 to provide fully for interest and amortisation charges.

* * * *

Munich Local Railways in 1933

The report of the " L.A.G.," the Local Railways Company of Munich, reveals that the alarming decline in receipts prevalent during 1932 was practically arrested during 1933, the total receipts of 2,449,142 RM as against 2,507,889 in 1932 showing a decrease of only 2·3 per cent. The 1932 decrease was no less than 22·43 per cent. Goods traffic increased from 459,527 to 485,091 metric tons, the receipts therefrom dropping from 893,665 RM to 885,721 RM, a decrease of roughly 1 per cent. In passenger traffic, the total number of persons carried decreased by 1 per cent. as against 15·7 per cent. in 1932, while the passenger receipts dropped by 4·5 per cent. as against 21·3 per cent. in 1932. In spite of the fact that no increase in receipts is yet shown, the " L.A.G." has pluckily risen to the occasion in the general drive against unemployment, and has given continuous work to some forty men, in addition to the permanent strength of 1932. During the year, the 48-hour week has been in operation. By order of the Munich Landesgericht, dated November 9, 1932, the transfer of the Stadtamhof-Reinhausen line of the Valhalla Railway to the Regensburg Corporation came into effect, and since October 1, 1933, through bookings between the Valhalla Railway and the Regensburg tramway system have been in force.

* * * *

The Port Eglinton Collision Acquittal

We briefly recorded last week that on Wednesday, January 30, the Sheriff's jury found driver Kerr " not guilty " of the charge of culpable homicide arising out of the fatal collision at Port Eglinton, Glasgow, on September 6. It is worthy of note in this connection that the Scottish courts have an alternative to the usual verdict of " guilty " or " not guilty "; namely that of " not proven." A verdict of " not guilty " in a Scottish court is thus of greater significance than would be one of " not proven." The present is not the moment for us to discuss the circumstances of this accident, as the opportunity for doing so will now soon arise on the publication of Colonel Mount's report. That document has, in accordance with the usual practice in such cases, been kept back so that the inspecting officer's opinions should not influence, favourably or adversely, the trial of driver Kerr. It suffices for the present to say that Kerr maintained that the advanced starting signal at Shields Road was at " clear " when he left that station and that when he saw the Port Eglinton home signal it also was " off." Knowing thus that he had a clear road, he increased his speed to take his train up the gradient that approaches Cumberland Street station. As his engine was running tender first he had to turn round to do so and when he again looked at the signal he saw that it was at " danger."

The Divided Train Staff

A note in the annual report for 1933-34 of the New South Wales Government Railways as to the introduction of what is described as the divisible train staff, permits reference to this type of electric train staff working. We would first say, though, that in the United States, where the train staff was introduced in 1894, both halves of the divided staff are carried by the same train; the driver takes one half and the rear brakesman carries the other. Both halves must be again joined, so ensuring that the arriving train is complete, and inserted in the instrument at the farther end of the section before train-out-of-section can be sent. As used in New South Wales and in other parts of the British Empire, as well as in South America and elsewhere, the divided train staff allows for two trains to be in a section at the same time; the first train has what is called the " ticket " portion and the second train has the other, or " staff " portion. Both trains must therefore be accepted by the box in advance, and thus protected against head-on collision, and both must be cleared, before either signalman can withdraw another staff.

* * * *

The Station Becomes the Market Place

An illustrated booklet received from the French State Railways gives further evidence of the diverse activities now carried on beneath the roofs of certain Parisian termini. An editorial note in our issue of June 8, 1934, drew attention to the conversion of the circulating area at St.-Lazare into a comprehensive multiple store, and it now appears that this is an expression of the brighter station policy as it is understood in France. The foreword to the booklet draws an apt comparison between the market place, formerly the scene of arrival and departure by stage coach and consequently a centre of commerce, and the modern railway terminus. It criticises the atmosphere of even the more sumptuous stations of past decades on the grounds that their appointments did nothing to mitigate that vague *ennui* of waiting travellers which inspired the title of *salle des pas perdus*. To make the station a place of buying, selling, amusement, and the dissemination of propaganda for local enterprise is the suggested remedy, which the State Railways have already applied both at St.-Lazare and Montparnasse. Several pages of the booklet illustrate the idea put into practice at these termini, and there is a two-page plan representing the combination of facilities for purchase which the well-equipped station should provide.

* * * *

The " On Time " Ideal

A correspondent in the February issue of *On Time*, the journal of the L.M.S.R. Operating Department, suggests that were every one of the 118,000 individuals directly concerned with the working of trains to save a minute a year, the collective gain so secured would be 13¾ weeks. A very genuine enthusiasm for punctuality must have inspired a calculation of such magnitude as this, and whether we are moved to verify the result for ourselves or to accept it with the humility of those to whom figures habitually lie, it cannot fail to be a source of inspiration in idle moments. Following this comes a letter from an author who asks whether the " on time " ideal is really the be all and end all of railway working, suggesting that safety and punctuality are not always compatible. The objection holds good for some forms of transport. Time to the private motorist, for example, is a factor which frequently is pressing only when he is half way through his journey, and this introduces an erratic element into

the flow of road traffic which complicates the working of services bound by fixed schedules. But when it is adhered to continuously and universally, a timetable becomes, as it should be, a promoter of safety in itself, and this is what we understand by the " on time " ideal.

* * * *

The World's Fastest Inter-City Service

Chicago and Milwaukee can now boast the fastest intercity train service in the world. As an outcome of the record run of July last, when a 4-6-4 locomotive of the Chicago, Milwaukee, St. Paul & Pacific RR. covered the 85 miles separating the two cities in 67 min. 35 sec., maintaining an average speed of 89·9 m.p.h. over the 68·9 miles between Mayfair and Lake, 90-min. timings were instituted between Chicago and Milwaukee. This schedule has now been cut to 85 min., and five trains—three in the southbound and two in the northbound direction—are now so scheduled, involving a start-to-stop average of 60 m.p.h., which includes the slow running necessary within Chicago city limits. Spurred on by this competition, the Chicago & North Western RR., as announced on page 83 of our January 18 issue, has already instituted a booking of 80 min. in both directions between Chicago and Milwaukee, entailing an average start-to-stop speed of 63·8 m.p.h. over a route of the same length. Further competition is provided by the Chicago, North Shore & Milwaukee RR., an inter-urban line which, as fully described in the *Electric Traction Supplement* of our January 11 issue, has the fastest electrically-operated train service in the world, with start-to-stop bookings of from 60 to 70 m.p.h., and overall averages, between the suburbs of the two cities, of 60 m.p.h. inclusive of stops. Mile-a-minute service is thus offered by three different routes.

* * * *

Still Higher C.M. St. P. & P. Speeds

Apparently the new Chicago, Milwaukee, St. Paul & Pacific high speed services, referred to in the previous note, are no more than an earnest of considerably higher speeds that are in contemplation in the spring of this year. For these important developments, the full details of which are not yet finally decided, special rolling stock is in course of construction, and it is a matter for comment, after the recent experimental runs by diesel-operated units at record speeds, that reliance is still to be placed on " Old King Coal " for the maintenance of the new service, which will connect Chicago with St. Paul and Minneapolis by way of Milwaukee. A new type of streamlined locomotive with roller bearing axles has been designed, embodying various features intended to make possible higher sustained speeds than ever previously attempted with steam locomotion. The coaching stock, like the locomotives, will also have Timken roller bearings, and will be streamlined, with the rear end of the hindmost coach in each set rounded, in order that the maximum possible benefit may be derived from the streamlining. A new type of day coach has been designed, and a café car and a parlour car will be included in each train. The route over which these trains will operate is double-tracked throughout, and equipped with the latest signalling and mechanical devices to permit of safe operation at the speeds contemplated.

* * * *

Immortal Locomotives

In his judgment on the Southern Railway Rating case, recorded in our News Section this week, Mr. Justice Mackinnon, referring to the practice of British railway companies of keeping their rolling stock in as near a condition of perfect efficiency as possible by a complete overhaul and renewal of parts every few years, said that, if the perfect type of engine was evolved, it might, in a sense, be immortal. Which saying immediately conjures up visions of certain types of locomotive that come as near to being within this category as is consistent with the progressive development of mechanical engineering. The outstanding examples are probably the Ivatt Atlantics on the L.N.E.R. and the Midland compounds on the L.M.S.R. Both types, of which large numbers were built, and of which not a single specimen has yet gone to the scrap heap, made their first appearance well over thirty years ago, and both types still put up excellent performances in fast main line express services. They remain substantially as originally built, except for the addition of superheaters and certain modern detail refinements, but it is doubtful whether there are actually any parts which have not been renewed in the course of their periodic overhauls. They are a lasting memorial to the foresight and ingenuity of their designers.

* * * *

The Short-Lived Locomotive

On the other hand, there are locomotives, designed specifically for fast and heavy main line service a much shorter time ago than those referred to in the previous note, that have already gone the way of all things. Some specimens of such types have, indeed, been scrapped after less than ten years' service, the reason being, obviously, that a so much better design had meantime been evolved as to render them not worth the expense of heavy overhaul. Notable examples that come to mind are the " Claughtons " of the L.M.S.R., certain of the Drummond four-cylinder 4-6-0's on the Southern, and the later 4-4-0's of the G.W.R., all of which have already gone, or are now on the way to the scrap heap, although none was built thirty years ago. It is not, of course, necessarily that the designs were intrinsically faulty. Other reasons, such as traffic developments, the economy of maintaining only standard types rather than small numbers of special types, and the reorganisation of workshops to build and rebuild standard types, are all factors bearing on the length of locomotive life.

* * * *

Locomotive Numbering

The decision has been reached by the administration of the Paris-Orleans-Midi Railway of France to renumber the whole of its locomotives on a new and systematic plan similar to that in use on the French State and the P.L.M. Railways. The principle of enumeration is that of adopting, as a prefix, the type or series number of the class to which the locomotive belongs, expressed by its wheel arrangement, with the actual number of the engine in that class then following. For example, the twelve Pacifics rebuilt as 4-8-0 locomotives with all the latest improvements, and which are now performing notable work over the Toulouse main line, have had their original numbers, 4701 to 4712, altered to 240.701 to 240.712 inclusive. The various classes of Pacifics have the prefix 231 to their numbers, corresponding in axles to the 4-6-2 wheel notation adopted in this country and America. One of these is illustrated on page 248. The P.L.M. method of locomotive numbering goes further, for, in addition to giving the axle arrangement of the locomotive concerned, it also indicates the particular class in that wheel arrangement to which that locomotive belongs. For example, No. 231.G.256 is No. 256 of the Pacific series, Class G, with double trefoil blast-pipe, double chimney, lengthened valve-travel, A.C.F.I. feed-water heater, and improved lubrication. This comprehensive method of numbering makes for ready identification of the type of any given locomotive from its number.

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Locomotive Performance in France

FREQUENT references have been made in past issues of THE RAILWAY GAZETTE to the systematic improvement in the efficiency of the steam locomotive which has been proceeding during recent years in France. The patient researches of the Paris-Orleans locomotive authorities into the generation of steam in the locomotive boiler and the facilitation of its flow from the moment it passes the regulator to its exit from the chimney, have directly influenced the locomotive practice of every railway in France. Not only have these modifications increased the thermal efficiency of all the locomotives which have been converted on the lines first developed in the P.O. Pacific rebuilds, but their value has been passed on to the French public in faster schedule times, on the P.O. and P.L.M. systems in particular—specifically credited by the managements of the railways concerned to the increased tractive power of rebuilt locomotives which had already been in service for a considerable number of years—and also in an even greater capacity than before for the recovery of lost time, which, as is generally known, is an established custom on French railways.

In this and a succeeding number of THE RAILWAY GAZETTE remarkable details, received from a Paris correspondent, are given of the current performances of some of these reconditioned locomotives. On the Paris-Orleans main line to Bordeaux, for example, a rebuilt 4-6-2 had to handle a train of 784 tons out of St. Pierre-des-Corps, and had already performed such feats as mounting a 7-mile incline averaging 1 in 225 at a minimum speed of 52·5 m.p.h. and an average of 56, and a start-to-stop run of 29·5 miles from Ruffec to Angoulême in 31 min. with a maximum speed of 78 m.p.h., when a drawbar in the train was broken in restarting from Angoulême. This resulted in a loss of 28 min. and an increase of the load to 807 tons. With the laconic comment " we shall have to work " to his fireman, the driver then succeeded in regaining 7 min. to the next stop alone, and 15 min. in all to Bordeaux, mounting the 12-mile incline to Charmant tunnel, varying chiefly from 1 in 250 to 192, at a steady speed of 53-54 m.p.h., with the boiler supplying steam for 60 per cent. cut-off in the h.p. and 58 per cent. in the l.p. cylinders, and a steam temperature, in the h.p. chest, of 790° F., so that the 50·6 miles from Angoulême to Coutras were covered start-to-stop in 50 min. On the Est main line a 79-ton 4-6-0—one ton lighter than a G.W.R. " Castle " 4-6-0—after rebuilding on similar lines, showed itself capable of hauling a 380-ton train up 6¼ miles of 1 in 125 at a minimum of 49 m.p.h., and of maintaining 70 m.p.h. on the level with 600 tons behind the tender; in the latter case 100 miles were covered at an average speed of 67 m.p.h., and yet on a coal consumption (including a proportion of slack) no greater than 45 lb. a mile. In assessing these runs it should be remembered that the loads hauled are computed gross tonnages and include an allowance for passengers and luggage, calculated as described in our article.

Proportionately to the weight of the engines concerned, some of the performances detailed in this article must be of a more exceptional description than has ever previously been set on record, either in France or in any other country. They are partly, of course, the fruit of the considerable improvement in design to which we have already drawn attention. Partly, however, they must be attributed to the systematic course of training through which a French driver passes, which enables him to make the best possible use of the modern accessories with which his engine is equipped, and also to the inducements which are offered him and his fireman to exploit to the full their knowledge and experience. The coal bonus makes for economy in coal consumption; the time-recovery bonus is the reasonable reward for attempting to recover time lost by causes not under the control of the crew; and the safety of passengers, who stand to benefit considerably by this attention to strict timekeeping, is doubly secured, first by the self-recording speed indicators on the locomotives, which check over-exuberant running round curves, and also by the fact that time recovery restores trains as rapidly as possible to their proper booked paths. From the particulars given, it will be seen that no load is so great as to deter French locomotive crews from their persistent attempts to recover lost time, as witness the gain of 15 min. between Angoulême and Bordeaux with a train of over 800 tons.

Furthermore, these reconstructions have placed in the hands of the French operating authorities machines capable of dealing with the maximum conceivable conditions of train-loadings. Loads up to a total of 905 tons have been handled on the P.O. line without pilot assistance. It is not in our view generally desirable that such maximum loadings as these should operate on day services, as very few station platforms, in this country, at any rate, can accommodate formations of this vast length, and station delays would be inevitable were 600-ton loads and more to come into general use. The desideratum in the daytime is frequent service of more moderately-loaded trains at high speeds, and to this, of course, the French modifications of design lend themselves just as admirably as they do to the handling of the very heavy loads figuring in this article. But economies could be effected in the working of British night services, which do not call for high speeds, were tractive effort per unit of locomotive power on so high a scale as that which we have described. Night expresses between England and Scotland, run in duplicate throughout the year, and in triplicate and more during the summer, might be run in combination, for lengthy formations are not so troublesome at night, when the great majority of passengers are making through journeys, as they are in the daytime. In any event, these French locomotive performances are worthy of close study. They appear to open up new possibilities in steam traction.

* * * *

Rail Repairing by Acetylene Welding

AT the eleventh International Acetylene Welding Congress held in Rome last year a report presented by Mr. Zygmunt Dobrowolski on the work of repairing worn rails since 1931 on the Polish State Railways provided some interesting information. The practice adopted in Poland was based on experience acquired in the U.S.A. where, according to a report by Mr. C. R. H. Howe of the Chesapeake & Ohio Railway to the 35th Annual Convention of the International Acetylene Association at Pittsburgh last November, 504,000 battered rail joints are being repaired annually by the oxy-acetylene process as against 407,000 by the electric arc method. In 1931 the Association for the Development of Welding and Cutting in Poland submitted to the Polish Ministry of Communications a proposal to carry out experimental work, and the Perun Company, with the Gas Accumulator Company, as members of the association, offered to undertake this work gratuitously. The offer was accepted and, as indicated below, very satisfactory results have been achieved. On the Katowice section of the Polish State Railways, where the heaviest traffic is carried, 300 crossings have been repaired and have demonstrated the advantages of this method of treatment. In the Poznan division battered rail ends have been built up and broken fishplates repaired with success, and the reconditioning of rails taken

out of the track for surface defects has been successfully undertaken by the Pomorze division.

The method of repairing worn crossings is very similar to that adopted, and already described in THE RAILWAY GAZETTE, for electric arc welding. Grease is first removed with a wire brush or burnt off with a blowpipe, chips are removed with a chisel, and first the wing rails are built up and subsequently the nose; the height of the deposited metal is measured by means of a straight-edge. A blowpipe of 150 litres per hour capacity is used, and the welding is done crossways, each run being hammered immediately after depositing. On the nose, welding is begun at the point and worked towards the throat or splice. The hammering of the filling metal must be done at a sufficiently high temperature to be effective, and the blowpipe must be directed on the weld area during hammering. While the rail head is still hot any excess metal on the surface is removed with a chisel. The hammering of the last layer should leave the surface smooth enough to obviate the necessity of grinding. Welding may be carried out while traffic is running, but, in order to avoid damage to the deposited metal, welding should be stopped shortly before a train passes.

Opinion is still divided as to the best type of rod to use for depositing on the worn rail, and various special steels have been used. The time and material used depends, of course, on the depth to be built up. This amount has varied between 7 mm. and 16 mm. on the wing rails, and the corresponding consumption of steel rod required has been 1·5 to 5·5 kg. per crossing. The corresponding consumptions of oxygen and acetylene respectively have been 4·2 cu.m. and 4·4 kg. (for the 7 mm. repair), and 9·0 cu.m. and 0·5 kg. (for the 16 mm. repair). The total time taken to repair a crossing has been 4·7 hours for the 7 mm. build and 9·3 hours for the 16 mm. build, but this, of course, may vary. In addition to the above mentioned types of repair, switch blades have been built up by the oxy-acetylene process, although these required specially careful treatment owing to the flange pressure exerted against them. For this reason rapid cooling must be avoided. Crossings rebuilt with chrome-manganese steel rod have given a Brinell hardness of 290-310 against 200-240 of the adjacent rails themselves. Worn parts of point mechanism, such as cranks, have also been repaired at the same time. The pre-heating of the rail which has been found desirable as a precaution, especially during cold weather, against cracking when arc welding is used is not found to be necessary with oxy-acetylene as a separation operation, since all that is necessary in this method is to direct the blowpipe flame on to the rail before bringing the filler rod into its zone.

* * * *

Locomotives on Curves

THE behaviour of a vehicle passing round a curve at speed, and the forces produced on the wheels and rails by its passage, is a problem in railway mechanics that does not lend itself easily to solution. It is, moreover, a problem of the greatest importance to all departments of railways seeking to obtain longer life from tyres and rails and to work their trains at the highest speeds compatible with safety. Any vehicle passing round a curve is guided by means of the forces acting at the treads of one or more wheels. Derailment occurs when the flange mounts the rail or overcomes the resistance of the rail to overturning. Until 1883 it was generally supposed that centrifugal force pressed the flanges of the end wheels of a vehicle against the outer rail, but this was refuted by very precise experiments with models performed by Mackenzie.* His paper is the foundation of our present conception of the motion of a vehicle on curved track. As a pair of wheels are rigidly connected by the axle, they cannot pass round a curve without relative sliding taking place, but in any vehicle or truck it is possible to find a point where an imaginary wheel of the same diameter would roll without sliding. This conception is due to Von Helmholtz, who gave some rules for determining the position of such a point, but neglected the fact that the forces of friction and the flange forces are not lateral, which gives exaggerated values for the latter. Boedeker, however, in "Rad und Schiene," took into account the longitudinal forces of friction of the wheel treads.

The next step was due to Ubelacker, who considered all forces acting on the wheel treads and was able to locate the position of the imaginary wheel which he called the "centre of friction." But in doing so he assumed that this point coincided with the point where a perpendicular from the centre of the curve would cut the longitudinal axis of the vehicle. Later, Heumann used this assumption to give a graphical construction for determining the frictional forces at the wheel treads, and thus the flange forces. In other words, all investigators had been unable to give a solution to the problem without assuming that the vehicle set itself in the curve in some defined way. Elsewhere in this issue we publish Appendix V to the late Mr. S. R. M. Porter's paper entitled "The Mechanics of a Locomotive on Curved Track." This paper was published serially in the issues of *The Railway Engineer* (now amalgamated with THE RAILWAY GAZETTE) dated July to October, and December, 1934. Appendices I to IV appeared in *The Railway Engineer* of January, 1935. The paper itself is a development of Ubelacker's work on the subject, and carries it to a conclusion. The author shows that a locomotive of any wheel arrangement can be considered as a number of trucks linked together, a truck consisting of any number of wheel pairs held parallel in one frame. He shows that the forces at the wheel treads determine the position of the centre of the friction, and that this can be calculated from the equations of motion of the truck. For a truck to be in equilibrium the resultant of all frictional forces at the wheel treads plus all other known forces, such as tractive force and centrifugal force, must be equal and opposite to the resultant of the flange forces acting at those wheels of which the flanges are in contact with the sides of the rails.

A truck of normal design can run in two ways—with one flange only in contact with the rail, or with two flanges in contact so that its position relative to the curve is positively determined. These cases are termed "free" and "constrained" curving, and there is no doubt in any particular case which will occur. A manifestly impossible solution will result if the wrong equations are worked out. In all cases, however, the solution of the equations of motion depend on the values given to the coefficient of friction between wheels and rails. In the absence of exact knowledge the author has used two hypotheses, that of "sliding," mainly used on the Continent, and the "creep" hypothesis supported by Carter in England. The experiments of the Dutch and German commission to investigate friction between wheels and rails seem to show that the value of the coefficient varies. On curves of large radius, where little relative motion takes place, creep occurs, while sliding is found on sharp curves. An exact determination of the value of this coefficient will render the paper of great practical significance as a means of improvement in locomotive design, and particularly in the design of high speed locomotives and railcars.

* *Proc. Inst. C.E.*, Vol. LXXIV, pp. 1–57.

XUM

LETTERS TO THE EDITOR

(The Editor is not responsible for the opinions of correspondents)

Overseas Railways Number

Kenya and Uganda Railways and Harbours
General Manager's Office, Nairobi.
January 10

TO THE EDITOR OF THE RAILWAY GAZETTE

SIR,—Will you allow me to congratulate you on your special Overseas Railways number. I think it shows great enterprise on your part to have got out a special number of this nature, and I am sure it will be read with great interest by railway men all over the world.

I have myself already found a large number of points in the practice of other railways which will be of assistance to us here. I was, too, particularly struck with Beyer-Peacock's advertisement on pages 6 and 7 and especially with that section of it which deals with Garratt locomotives used on this railway.

It is, however, always a matter of some surprise to me that the technical press does not as a rule find the operating results of Colonial railways of sufficient interest to justify a reference to them. I know that comprehensive summaries of annual reports are published, but it always seems to me that the technical railway man would be very much interested in the operating and statistical figures which are published in such detail in the annual reports of Colonial railways. I hope, therefore, you will be able to do something in this direction when our own annual report appears.

With kindest regards and all best wishes for the GAZETTE for 1935.

Yours faithfully,
G. D. RHODES,
General Manager.

British Passenger Train Services

The Ridge,
Frodsham.
February 1

TO THE EDITOR OF THE RAILWAY GAZETTE

DEAR SIR,—I should be grateful if you would allow me a little space for a few remarks on present-day British passenger train services. First of all, however, I should like to comment on the gradual change discernible during the last few years in the attitude of THE RAILWAY GAZETTE to any shortcomings, actual or alleged, on the part of the railways. If I may take the liberty of saying so, it appears to me that the somewhat complacent attitude of a few years ago has given place to a spirit of helpful and constructive criticism, which should be of the greatest value to the authorities.

The tables in your issue of December 21 showed in most illuminating fashion the comparative stagnation of express schedules in this country during a period when the greatest possible urge for improvement has existed, and does exist, in the shape of diminished passenger receipts, intensified competition from the roads, the commencement of competition from the air, and, in addition, an unparalleled stimulus of good example from all over the world.

British railways, in the early years of this century, were not only the best, but also the fastest in the world. It is, perhaps, fortunate that the British public to-day, half-informed by the bulk of the daily press about occasional accelerations, is largely ignorant of the astounding progress made abroad. How many travellers know, for instance, that a train of the Flying Hamburger type would bring Manchester and Liverpool within about 2½ hours of London; and Edinburgh or Glasgow within 5½ to 6 hours at most; or that the fastest train from Liverpool to London barely reaches the average speed of ten services between Paris and Brussels; or that Manchukuo, according to published plans, will have a high speed streamlined train in service before Great Britain; or that the Flying Scotsman would require to be accelerated by no fewer than two and a half hours to Aberdeen, to equal the speed of the Côte d'Azur express from Paris to Marseilles? Yet these things are so.

But it is not merely in the speed of the principal main line services that there is much leeway to make up. I would go further, and say that, in spite of recent improvements, the present timetables are in urgent need of a very drastic overhaul in many directions. Your editorial comments of December 21 drew attention to one serious fault, namely, the duplication of the times of services by alternative routes, instead of a rational spacing out which would give a better service without extra mileage. It might have been added that not infrequently, where such overlapping services exist, none of them is adequate for modern requirements. For example, one can travel to Sheffield from Marylebone at 8.45 a.m., King's Cross at 8.45 a.m. or St. Pancras at 9 a.m., arriving at 12.23, 12.39, and 12.16 p.m. respectively, but none of these can be described as a really good morning service to a town of Sheffield's importance, distant only 158½ miles from London.

Another serious shortcoming is the lack of really good services at certain times when they are most wanted by business men. There is no need to give examples; the timetables furnish plenty of them. And what of cross-country services? The best time from Liverpool to Newcastle, a distance of about 172 miles by the shortest route, is 4 hr. 38 min., and this not very distinguished average of about 37 m.p.h. can be achieved only by changing stations at Leeds. Such services, actually inferior in many ways to those of pre-war days, are a direct invitation to travel by road, and instances could be multiplied over and over again. Then, what of local services, in which, quite often, one sees a three or four coach train, possibly hauled by an engine once employed for expresses of three or four times the weight, but not accelerated by even a few odd minutes from its schedule of a quarter of a century ago? And what of Sunday services? But if I were once to start upon this topic, I should not know how to stop.

Why are the improvements so obviously needed, so long delayed, and why are the improvements actually made not more systematic and far reaching?

In conclusion, would it be impertinent for a layman to suggest that there appears to be scope for some sort of joint committee of experts, drawn from the commercial, operating, engineering and research sides of the various companies, whose duty it would be (*a*) to carry out a comprehensive critical survey of existing services, (*b*) to consider in what respects these fall short of modern standards, and (*c*) to arrange for the drawing up, by the companies concerned, of new schedules, which should not be only up to, but slightly ahead of, present-day requirements?

Yours, etc.,
W. G. POLACK.

ECHOES OF THE LISTOWEL AND BALLYBUNION RAILWAY.—Recently Mr. Justice Johnston, in the Irish Free State, granted permission to the executors of Mr. H. E. Crawley, representing the former debenture holders in the Listowel and Ballybunion Railway Company, to accept offers ranging from £1 to £150 for some 13 lots of property belonging to the railway company. The latter sum was in respect of a house formerly part of Ballybunion station. This line, which was built on the Lartigue mono-rail system, was opened in 1888, but closed in October, 1924, as the result of road competition and subsequently dismantled. The remaining properties are being sold to realise something toward the £11,000 judgment mortgage with 5 per cent. interest held by the debenture holders.

PUBLICATIONS RECEIVED

Socialisation and Transport. By the Rt. Hon. Herbert Morrison. (Cheap Edition). London: Constable & Co. Ltd., 10-12, Orange Street, W.C.2. 8 in. × 5 in. 313 pp. Price 2s. 6d. net.—This volume appeared originally in May, 1933, after the London Passenger Transport Board had been established, but before it had begun operations. As we then pointed out, in our review in THE RAILWAY GAZETTE of June 2, 1933, Mr. Morrison undertook the writing of this work in order to expound the policy which guided him in preparing the L.P.T. Bill and conducting the various negotiations with then-existing transport agencies. As such it is a valuable reference work, and the production of a 2s. 6d. edition should place it at the disposal of a wider market than the original issue. Moreover, Mr. Morrison discusses the management of publicly-owned industries generally, but with especial reference to British national transport and to the Socialist policy of bringing it under public ownership.

Red Road through Asia. By Bosworth Goldman. London: Methuen & Co. Ltd., 36, Essex Street, W.C.2. 9 in. × 6 in. × 1½ in., 273 pp. with index, bibliographical index, map and illustrations from photographs by the author. Price 12s. 6d. net.—This is one of the best travel books we have read for a long time. Mr. Goldman does not possess the whimsical philosophy of Dr. Malcolm Burr, but the Red Road bears the same stamp of absolute genuineness as Dr. Burr's book "In Bolshevik Siberia." Mr. Goldman undertook, very bravely, to travel from Newcastle-on-Tyne to Turkey via Central Asia.

He started out on a Welsh tramp steamer, and at no point until he joined the Orient Express at Istanbul, did he experience anything more luxurious than this. The river steamer up the great Yenisei was an eye-opener to begin with, and it was here that the author made a long and lasting acquaintance with the voracious Russian bed bug. He joined the Trans-Siberian Railway at the uninviting town of Krasnoyarsk. "The Manchurian Express crept into the station; labels were on its side 'Moscow-Vladivostok'; the passengers looked as dirty and worn as the train itself. 'It has a long way to go still' said the drunk; so it had, either way."

Space will not permit of our commenting on the many features of official and domestic life under the Soviets, though the author observes throughout a strict degree of impartiality. No, perhaps it would be fairer to say almost throughout. It is noticeable that he feels a distinct falling off in his willingness to be friendly after the Ogpu had confiscated his camera at Tashkent. This was only natural; to be arrested and to have one's camera taken away at three o'clock in the morning after a devastating journey on the Turksib is enough to spoil anyone's temper. The trouble was that Mr. Goldman had photographed the guard of his train talking to a stationmistress, and the background of the picture contained part of the train itself, headed by a tall-chimneyed antique of a locomotive. The northern part of the Turksib is of pre-war date and terribly badly laid. All the engines have to be old ones, as they are light and less likely to damage the permanent way. "The engine driver . . . wished he could go back to England with me, or, better still, to America, where he would be able to drive a bigger engine." In Armenia, a Persian "was enthralled by . . . an 1898 *wagon-lit* which had recently arrived from Leningrad: 'Is it true that abroad there are whole trains like that?'" This book should appeal to all who are interested in railways.

Selling in India.—"Why and Where," a monograph the name of which follows the explanatory line "Selling through newspapers of India," has a foreword by the Hon. Sir B. N. Mitra, K.C.S.I., K.C.I.E., the High Commissioner for India. It sets forth the commercial outlook in India and its trade prospects, as an aid to would-be traders with that country, and is published with a view to encouraging firms to advertise with a number of selected publications in India. These include, *inter alia*, the North Western Railway time book, and are all represented in one London office, a factor that secures considerable economies in many directions. As the High Commissioner surmises, the policy advocated by the monograph should be of considerable advantage to both advertisers and the progressive publications it sponsors.

Signal Winch and Gate Stop Lever.—We have received from the Westinghouse Brake & Saxby Signal Co. Ltd. an illustrated leaflet describing a combined signal winch and gate stop lever for the protection of level crossings. The apparatus is designed for situations where the crossing gates are neither operated from nor controlled by a signal-box block post, but owing to lack of view must be protected by distant signals to warn enginemen whether they are open or closed. Now that the signals must be placed at least 800 yards from a crossing, the usual arrangement of a three-lever ground frame for gate-locking and signal control is frequently unsuitable for operation by women or partially disabled men crossing keepers.

In the new apparatus, both signals are worked by a single winch, hand-driven through worm and bevel gearing. Not only does this make the work of winding very light, but it obviates the need for a catch to hold the signals at "off." A declutching lever disconnects the drum and allows the signals to return to "danger" under the influence of their own balance weights. This lever is interconnected with the gate locking lever so that the latter cannot be released until the signals are "on." Similarly, the signals are disconnected from the winding handle until the gates have been locked.

The Answer to Drilling Problems.—A conversation between Mr. Kostcut, the persuasive representative of William Asquith Limited, Halifax, and his shrewd client, Mr. Getworth, forms the main part of this instructive illustrated catalogue of the firm's O.D.1 and O.D.2 radial drilling machines. Since the answers to Mr. Getworth's questions lend themselves to graphical elaboration, and Mr. Kostcut pays his calls with pockets full of appropriate diagrams, the eavesdropping reader has learned much by the time the concluding stages of the transaction are reached, and Mr. Kostcut appeals to him—as Tinkerbell calls upon the audiences at "Peter Pan" to confirm their belief in fairies—to say what *he* would do in Mr. Getworth's place. His answer should by this time be clear, and he will proceed with an easy mind to the study of the second part of the catalogue, in which the constructional features of the drilling machines are fully illustrated and described. Novel features are the self-acting feed, which automatically operates as soon as the drill point is brought into contact with the work, and the auxiliary high-speed spindle supplied for light drilling.

Aluminium Facts and Figures.—The British Aluminium Co. Ltd. has published a handbook under the above title which assembles in a convenient and durable form a wide range of practical data and advice for users of the metal and its alloys. The first portion of the book is devoted to forms and sizes, giving specifications of sections, tubes, sheets, wire, and ingots, with dimensional drawings. The opportunity has also been taken to include a few pages of general information for engineers, such as metric and other conversion factors, formulæ, and physical properties of various metals. The remainder of the handbook deals with working and finishing. Welded joints by electric and oxy-acetylene processes receive necessarily brief but useful treatment. The methods of producing various finishes of the metal are briefly outlined. Paint can be applied to aluminium with considerable economy, as is demonstrated by the carriage-painting practice of one British railway, which standardises seven coats for vehicles so constructed against nine for steel and 12 for wood rolling stock. With 166 pages bound in stiff cloth covers, and a finger-tip index to assist in locating information required, the handbook will be of lasting service as a work of reference.

XUM

THE SCRAP HEAP

When a brewery lorry recently made a wild dash on the Hereford-Abergavenny road, came to rest on the wall and was overhanging the L.M.S.R. line, it knocked down on to the permanent way a railway notice which read: "Let the L.M.S. move it"!

* * *

ELK CHARGES TRAIN

An elk saw a goods train coming towards it along the line from Uleaborg to Nurmes, in north-west Finland. It stood defiantly in the middle of the track, lowered its head to charge, and waited. It met the engine full on—and was killed. Police came to the spot and took away the carcase, which they later sold for £4.—*A press report from Helsingfors.*

* * *

UNDERGROUND MOSCOW

From Moscow I learn that the construction of the underground railway there is nearly complete. In the course of excavations interesting archæological discoveries have been made. These include an intact ship of Peter the Great, battle axes, the city walls built against Tartar invasions, and monuments and household goods of early Tsars. The population of the city is now said to be 3¾ millions, making it the largest on the Continent. —*From "The Morning Post."*

* * *

A REACTIONARY RHYME

The following reflections are inspired by the poem "Streamline" which we published in our issue of February 1:—

Another bard has sung in praise
Of sveltness and the streamline craze,
So even I shall now aspire
To conjure from my humble lyre
A diffident but just defence
Of comfortable corpulence.

The locomotive is not used
To being forcibly reduced,
And loses half its airs and graces
When flattened in the bulbous places;
For dignity is best observed
In men and objects amply curved.

And similarly I applaud
A well-proportioned railway board.
He'll cry with me, who but reflects,
"Long may directors be convex,
And guard from every slimmer trend
The temperamental dividend!"

* * *

In connection with the closing on October 1 last of the Forth and Clyde Railway, Driver J. Curran, of Balloch, tells the *L.N.E.R. Magazine* the following story illustrating the free and easy manner in which the railway was run in its early days:—

"One day the driver of the morning train observed an old farmer running through the fields waving his umbrella, and thinking he was an intending passenger, stopped his train. When the farmer regained his breath, he shouted to the driver, 'Am no gaun wi ye, a jist want tae see if ther's onybody in the train can change a pound.'"

* * *

Which is the forgetful sex? Three out of four claimants for articles at the lost property office of London Transport, at Baker Street, are women. Among recent articles unclaimed are a skull, and a bicycle. On Armistice Day, 1934, the lost property bag included 901 umbrellas.

* * *

DRESSING-UP RAILWAYMEN

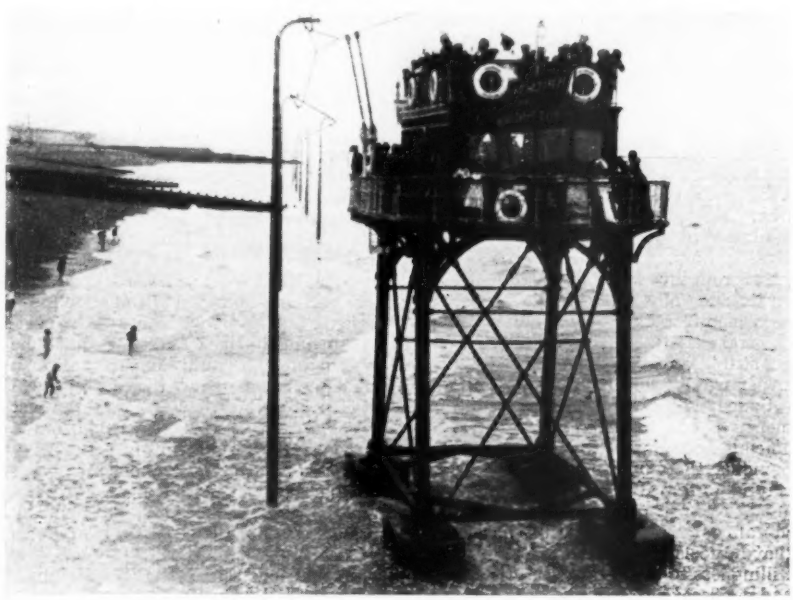
One of the most encouraging features of the railway renaissance is the way the big companies are worshipping more and more at the shrine of Beauty. Results are already to be seen in the form of devastatingly chic carriages, scrumptious new puffers, and irresistibly gay waiting-rooms. But their beauty treatment has not so far included their personnel. Physical considerations apart, the railway employee could hardly be called a Thing of Beauty or a Joy for Ever.

Think what a wonderful job the companies could make of the station-master—who at present, even with top hat, is at best a sombre dignitary. Why not give him a cocked hat, with plume, a richly braided tail-coat, with epaulettes, and the arms of the company emblazoned on his chest, streamlined knee-breeches, silk stockings, and shoes with chromium-plated buckles? And he might also wear a belt, to which would be attached his keys and a heavily embossed Bradshaw (hand-printed on vellum).

Guards could be made equally exotic. The first thing would be to abolish their whistles, and substitute some romantic instrument such as an oboe. As regards signalmen, the companies would be able to save considerably, since, being so rarely seen out of their boxes, the signalmen would only require redecoration down to the waist.—*Phipps in "The Daily Mail."*

* * *

One of the most interesting novelties in rail transport was that evolved at Brighton by Magnus Volk, the famous pioneer of electric traction. As early as August 3, 1883, he had placed in service the first electric line in Great Britain, and reference to the jubilee of this event was duly made in this column on August 11, 1933. Some years later Volk conceived the idea of an oversea car to run from the Banjo Groyne to Rottingdean, and on July 27, 1893, the Brighton & Rottingdean Seashore Electric Tramroad Company was formed. Naturally this formidable title never came into popular use, and the car, which we illustrate below, was generally called "Daddy Longlegs." It ran on two pairs of 2 ft. 8½ in. gauge tracks arranged with the extreme rails 18 ft. apart. The saloon car was 50 ft. long by 22 ft. wide, weighed 40 tons, and accommodated 150 passengers at deck level, which was 24 ft. above the rails. The inaugural run was on November 29, 1896. A few days later the car was badly damaged in the great gale of December 4, which carried away the Chain Pier. The "Daddy Longlegs" was repaired and set to work again by August, 1897, but finally abandoned early in 1901 when the Brighton authorities decided to lengthen various groynes.



The "oversea" electric railway at Brighton in 1898

OVERSEAS RAILWAY AFFAIRS

From our correspondents

INDIA

Indian Railways in 1933-34

The Railway Board's Administration report for the year ended March 31, 1934, shows signs of gradual recovery from the acute depression of previous years. The earnings of State-owned lines rose from Rs. 84 crores in 1932-33 to Rs. 86 crores, but this increase of Rs. 2 crores, attributable largely to improved goods movement, was insufficient to cover interest charges. The deficit amounting to nearly Rs. 8 crores was met, as in the two previous years, by a temporary loan from the depreciation fund. No contribution could be made to the general revenues.

The total earnings of all Indian railways, including lines with which the Government of India is not directly concerned, amounted to Rs. 99½ crores, the percentages of goods, passenger and parcels, luggage and miscellaneous receipts being respectively 62, 30 and 8. Passenger earnings recorded a fall of nearly a crore, while the receipts from goods traffic improved by Rs. 4¾ crores. Heavy traffic in raw and manufactured cotton, oilseeds and fuel contributed largely to the improvement. Important features of administrative improvement during the year included a further reduction of stores balances to Rs. 10 crores, constituting a fresh low record, and a reduction of expenditure on account of compensation for goods lost or damaged to Rs. 2¾ lakhs as compared with Rs. 120 lakhs in 1922-23 and Rs. 11 lakhs in 1928-29.

New Lines and Rolling Stock Developments

Twelve miles of new railway were opened during the year, and a further 50 miles were under active construction at its close. Satisfactory progress was made in the concluding stages of the Vizagapatam harbour works. The Ava bridge connecting two sections of the Burma Railways hitherto linked only by a ferry service was opened on January 2, 1934. The policy of replacing old locomotives by high-powered modern engines enabled the raising of the average tractive effort per steam engine from 25,045 lb. to 25,262 lb. on the broad gauge, and from 14,707 lb. to 14,906 lb. on the metre gauge. Various committees dealing with the standardisation of locomotives, carriage and wagons, bridges, tracks, signalling and interlocking, considered important questions with satisfactory results.

Punctuality and Safety

The year recorded an improvement in the maintenance of punctuality in the running of all passenger trains, the percentage of trains keeping time rising from 85·1 to 87·0 on the broad gauge and from 86·5 to 87·2 on the metre gauge. Though the number of accidents of all kinds increased by 944, there was a decrease in the number classed under " attempted train wrecking and train wrecking." The report concludes with an account of the " job analysis " inaugurated by Mr. Pope, whose second visit to India in the cold weather of 1933-34 was followed by a further report, now under consideration by the Railway Board.

Magh Mela at Allahabad

The Magh Mela at Allahabad has already started, and will continue till the middle of February. The first important bathing day at the " Sangam " or the confluence of the Jumna and the Ganges, January 14, drew a large gathering of pilgrims. The railway and civil authorities have made elaborate arrangements for the comfort and safety of the visitors. The East Indian Railway is taking steps to handle efficiently a very large pilgrim traffic between February 1 and 4. The special station at Prayag Ghat will be opened to traffic from January 30 to February 4. About 400,000 visitors are expected to visit the mela from various parts of the country.

QUEENSLAND

Expansion of Traffic

During the past few months the expansion in traffic has far exceeded expectations, with the result that the revenue for the five months ended November 30 last was £384,851 in excess of that for the corresponding period in 1933. This was due to a marked increase in livestock, timber and general goods traffic, coupled also with a heavier passenger business. Early and copious summer rains have fallen over most of the State and the prospects for the immediate future are bright.

Salary and Wage Review

The Arbitration Court recently dealt with the matter of salaries and wages in the Government service. Wages were fixed on the basis of the basic wage payable by private enterprise which represented an improvement of about 2 per cent. on the existing wage. Salaries were raised by a remission of one quarter of the deductions imposed under the Salaries Reduction Act. This will represent an improvement of about 3¾ per cent., but no relief has been afforded officers in receipt of more than £568 per annum, to whom the full salary reductions still apply. The review of conditions of service, allowances and other matters by the Arbitration Court is to take place early this year. The Government has made provision for automatic increments in accordance with the classification.

Appeal Against Supersession

For about thirty years the Queensland Railway employees have had the right of appeal to an appeal board against punishment inflicted by the head of a branch. The board consists of a police magistrate as chairman, with one departmental and one employee's representative. The right to appeal against the promotion of another employee, which has been withheld for about five years, has now been restored.

SOUTH AFRICA

Financial Position

The railway earnings from transportation services only, for the seven months, April 1 to October 31, 1934, totalled £15,385,962, an increase of £1,815,543 compared with the corresponding period of the previous year. Railway working expenditure totalled £10,537,795, an increase of £851,080. The accumulated deficit of £2,168,269 at the end of March had been reduced to 439,483, after taking into account contributions to betterment, pensions and superannuation funds amounting to £488,250. This improvement has also been continued as is shown by the fact that earnings for the four weeks ended December 22 totalled £2,296,288 an increase of £276,773 compared with the corresponding period of 1933.

Report of Controller and Auditor General

The audited figures for the year ended March 31, 1934, reveal that the operating ratio was 71·36 per cent., a satisfactory reduction of 4·25 on the previous year and the lowest recorded since the year 1917. Out of a total of 102 road motor area services, 78 showed a profit aggregating £47,222, the remaining 24 showing a loss of £5,116. A further loss of £9,011 was incurred on the miscellaneous account. The loss on grain elevator working for the year was £74,439, and on dining car services £14,157, as compared with £10,571 the previous year. A net profit of £19,079 is shown on publicity, bookstalls and advertising services. The bedding service shows a profit of £15,546 which is an increase of £7,379. The total staff employed was 81,216 as against 77,343 in 1933.

Entrance Examinations

The administration has introduced annual examinations for youths seeking appointment to the clerical staff. The principal object of the examinations is to test initiative, intelligence, general knowledge, neatness, accuracy, and bilingual attainments. The examination will consist of four two-hour

written tests in English, Afrikaans, general knowledge and accuracy, and will be restricted to candidates of 22 years of age or under who have passed the Junior Certificate or any equivalent thereof recognised by the Union Department of Education. Approximately 1,200 candidates will sit for the first examination which will be held in March, at between 50 and 60 centres throughout the Union. The examinations will be conducted by the Union Department of Education on behalf of the railway administration.

Locust Invasion

Resulting from the heavy hatchings of locusts in the Orange Free State, serious delays to trains were caused by the insects settling on the track. In October the administration equipped a special train with a 4,000-gallon tank truck filled with diluted locust poison from which both sides of the track were sprayed by means of a small pump on top of the truck connected to two hose lengths on each side. The results were so satisfactory that an additional train was equipped within a few days. After having completed their work in the O.F.S. they were sent to the Cape Midland districts for similar service there.

Road Motor and Air Services

Three new road motor services were introduced in December. Boksburg to Benoni (7 miles); an extension of the Middelwit-Rooibokkraal service to Thabazimbi (57 miles); and an alternative route between Merriman and Richmond (36 miles). On December 24 last 10,739 miles were being operated.

The increasing popularity of air travel, especially since the acquisition by the railway administration of the new Junkers Ju.53M aircraft, has resulted in the reintroduction of a daily week-day service between Johannesburg and Durban. The new machines have a cruising speed of 154 m.p.h. and the journey in each direction occupies only two hours. The service is so scheduled that it is now possible to travel from Durban to Johannesburg and back the same morning.

FRANCE

Metro Finances

The Paris Metropolitan Railway receipts in 1934 were fr. 516,495,360, as compared with fr. 509,571,711 in 1933, an increase equivalent to £92,315 at current rate of exchange. It must be remembered, however, that a greater mileage of line was in operation last year than the year before, but only 2 per cent. more tickets were issued. It may be of interest to recall that the construction of the Metro lines has been carried out by the City of Paris and the immovable property is the City's, but the rolling stock belongs to the Metropolitan Company which works the line on a concession from the City: this expires in 1955. Receipts are shared between the two parties concerned.

CHINA

Rolling Stock from Europe

Twenty new coaches are reported to have been received from Europe by the Lung-Hai Railway at Hsuchow in northern Kiangsu. An additional express was put on between Hsuchow and Haichow on December 2 last.

Shanghai Civic Centre Branch Line

The nucleus of the new civic centre of the Municipality of Greater Shanghai has now been laid out, and the construction of the branch line previously mentioned in our columns as taking off from the Woosung branch of the Nanking-Shanghai Railway at Kao-chiangmiao, will be begun early in the New Year. The new branch, which will be in the vicinity of Kiangwan—between Woosung and the Foreign Settlement—will be about 2 km. in length, and is to be completed by October next.

Peiping-Hankow and Peiping Suiyuan Earnings

On the former system revenue from all sources up to the end of October last was approximately $1,000,000 more than in the corresponding period of 1933, and as November and December are busy months a substantial improvement for the whole year is confidently anticipated. On the Suiyuan line also an increase of about $100,000 is reported on the first 10 months of 1934 as compared with 1933.

The sum of $190,000 has been allocated to the construction of the New Nanking Central station by the Ministry of Railways.

New Lines

So rapid has been the progress upon the construction of the extension of the Lung-Hai main line westwards from Tungkwan to Sian, the capital of Shensi, that the platelaying has now been completed throughout this 130-km. length of new railway, which was expected to be opened on January 1. The first 70 km. as far as Weinan were opened in July last, so that the remaining 60 km. have taken only six months to construct.

Meanwhile the first section of the Huainan Railway, in northern and central Anhui, was opened on December 17 from Lohochien in the Huaiyuan District to Hofei. It passes through the Tatung and Huainan coalfields, and is to be extended from Hofei *via* Chaohsien, east of Lake Chao Hu, to Yuchichen, in eastern Anhui, where it will link up with the port of Wuhu on the other bank of the Yangtze.

On November 25 last, public traffic was inaugurated on the Wuhu-Hsuan-cheng section of the Nanking-Wuhu Railway in south-eastern Anhui. The whole line is expected to be completed in March next. Meanwhile, the Tatung-Puchow Railway branch line from Taiyuan and Hsishan—13 miles in length and intended solely for carrying coal—has been completed. The main line also has been laid as far as Huohsien, 60 miles south of Kiehsiu, and traffic will soon be running over this section. Preparations are now being made for an early start upon the construction of the Soochow-Kashing Railway, which is to link Soochow on the Nanking-Shanghai Railway with Kashing on the Shanghai-Hangchow-Ningpo Railway. Work is to begin upon three sections simultaneously. The total length of this line will be 75 km.

CHILE

State Railways

Figures for 1933 show that the Chilean State Railways made a remarkable recovery as compared with 1932. Some of the more important are as follow, and are quoted from "Economic Conditions in Chile" (November, 1934), a report prepared by the Department of Overseas Trade:—

	1932	1933
Passengers carried	12,938,407	17,733,165
Passenger-kilometres ...	664,165,491	890,939,557
Tons carried ...	3,870,300	4,844,702
Ton-kilometres ...	873,358,312	1,046,363,085

The figures for 1934 also, have so far improved as to enable the railways to place important contracts for material abroad. British machine tool makers have already successfully tendered for the equipment of the machine shops at San Bernado, and it is hoped that further contracts now under scrutiny will bring additional useful orders to British trade.

New Rolling-stock

The State Railways have ordered from the German group, comprising Henschel, Krupp, and Esslingen, 25 200-ton locomotives and a number of wagons at a cost of 26 million Chilean pesos (approximately £548,000). [The locomotive orders were referred to in the Contracts and Tenders columns in our issue of January 11.—Ed. *R.G.*] In addition, a consignment of 10 locomotives and 15 coaches, constructed for the State system by the Baldwin Locomotive Works and the Bethlehem Steel Company, respectively, U.S.A., were recently delivered at Valparaiso: the engines were shipped already assembled.

British Railways in Chile

The British-owned railways also show considerably improved returns, especially during the first eight months of 1934, but due to fundamental exchange difficulties, their net financial results are seriously depleted in terms of sterling. Nitrate is the principal commodity carried by the Antofagasta & Bolivia and Nitrate Railways, and for this the following are the comparative figures year by year, those for 1934 being calculated for the whole year on the basis of actuals for the first eight or nine months.

	1932 Tons	1933 Tons	1934 Tons
Antofagasta & Bolivia Railway	26,969	102,934	160,260
Nitrate Railways ...	50,614	204,477	307,506

IMPRESSIONS OF OVERSEAS TRANSPORT

XI—American railways and their transport competitors. Shipping enterprise by the C.P.R. at Vancouver

By A. W. ARTHURTON, formerly Secretary, British Railways Press Bureau

THE real competitor with railways and public transport in North America is the private motor car. In the United States the proportion of cars to population is much higher than in Great Britain or any other country. In fact, practically everyone seems to own a car, even among the poorer sections of the population. The position in regard to the private car owner, however, appears to be undergoing a change. Not so long ago the motor car offered novelty and pride of ownership, and the cost of a car in the good times then prevailing was a matter of less importance. Now cost must be considered, values must be scrutinised and expenses must be balanced with income. Motor cars in the future will no doubt be used only when and where they serve best, as determined on the sole basis of their utility in providing transport cheaper and better than by other methods. When transport is sold in a normal market, with the public buying the service offering the greatest value for the money, public transport services prosper according to their merits.

Seventeen years ago, during the world war, Mr. Daniel Willard, President of the Baltimore & Ohio Railroad, who was then Chairman of the Advisory Commission of the Council of American National Defence, was asked to state his views on the future of transport in America. He concluded his statement with this paragraph: " The co-ordinated transportation system of a nation should be so adjusted that each unit will perform the particular function for which it is best adapted. And, speaking broadly, that country which is provided with the most efficient transportation—other things being equal—ought to be the most prosperous."

Many people did not agree with this view. At that time they visualised a continuous prosperity, with the railways continuing to carry the bulk of passengers and freight. Passenger travel by rail, however, declined so rapidly from the peak in 1929 that by the end of 1932, the worst year of the depression, passenger revenue had fallen off more than 70 per cent., in spite of the fact that, due largely to the motor car, travel increased enormously.

So far as freight is concerned, the competition of the motor lorry is very keen, both in Canada and the United States. The railways, however, are developing their collection and delivery services and employing their own vehicles on the road in many cases. Rates have been reduced under pressure of competition to an almost uneconomic level, and freight is being handled to-day by the railways faster and cheaper than ever before. Fresh fruits and vegetables all the year round at reasonable prices are the result of quicker and improved freight handling. Faster freight services and quicker deliveries have converted much of the general trade of the country from a wholesale to a retail basis, by virtue of which the storekeeper is now able to operate with smaller stocks and less capital, but this, as has been the case in Great Britain, means that consignments handed to the railroads for conveyance have tended to become smaller, so that more work is involved for less revenue.

Co-ordination is proceeding between rail and road passenger services. In some instances the railways run their own road services and in others they have shares in, or co-ordinating arrangements with established motor coach concerns. For example, on the Pacific coast the Southern Pacific Railroad has an interest in the famous Greyhound Line coaches. On the whole it would appear that the railways of North America, like those of Great Britain, have taken the measure of road competition and are concentrating on the facilities they are best able to provide, with a success which justifies the opinion that the trend of long distance passenger traffic is back to the train.

The C.P.R. and Sea Transport

Unlike their position on the road or in the air, the railways have a long tradition as agents of transport by sea. The Canadian Pacific Railway, as evidence of its faith in the potentialities of Canada's leading Pacific port, has invested a vast sum of money in wharves and a terminal at Vancouver. Planned with an eye to a prosperous future when Vancouver will become one of the greatest—if not the greatest—ports on the Pacific Coast, the C.P.R. has designed its pier B.C. to accommodate the largest liners that ply the Pacific Ocean. This extensive modern wharf, where liners of the " Empress " oriental fleet berth during their 12-day stay in Vancouver, is a far cry from the first wooden pile docks built by the C.P.R. in 1887. The present huge pier has nearly 3,000 ft. of berthing space available and accommodation for the cargoes of a dozen big ships at one time.

No open commercial seaport in the world can show such advantages in dock facilities as pier B.C. affords when compared with the original 1,000 feet of wharf. It cost $6,000,000 to build and is the second largest wharf in the world. Everything possible is provided to facilitate the rapid transhipment of merchandise from railway truck to ship or vice-versa. Electric cranes of large capacity load cargoes from freight cars which run on tracks the full length of the twin piers and are shipped into the holds of the waiting ships. The pier is served by eight tracks, sufficient to accommodate 200 railway cars. The pier was finished and opened for use in July, 1927, and represented nearly eight years of work and research by a small army of men. It was the first all steel and concrete ocean wharf to be built in British Columbia and is the latest and greatest example of the successful use of concrete piling for the sub-structure and of reinforced concrete and steel for the superstructure.

Besides Pier B.C., the Canadian Pacific Company owns Pier D, a large wooden structure which accommodates the nineteen steamships and four tugs of the British Columbia Coast steamship service, the Canadian Pacific coastwise fleet which serves Vancouver Island ports, the mainland, Alaska and Seattle. This pier is 800 ft. long and 200 ft. wide, and has a floor area of sheds amounting to 86,480 sq. ft. Connection with C.P.R. rail facilities is by means of three sets of tracks laid down the centre of the pier between the sheds. It has two berths for deep sea ships with a depth of from 28 to 30 ft. at low tide, and can accommodate as many as eight coastal vessels.

Other Canadian Pacific wharves in Vancouver are Pier A, which has two berths for deep sea ships, and Pier H, another wooden structure served by one set of tracks outside the pier. This also has two berths for deep sea vessels. The Pier station at Vancouver is a long cream-stuccoed building with red-tiled roof. The floor area of waiting rooms and offices is 225,000 sq. ft.

XUM

THE MECHANICS OF A LOCOMOTIVE ON CURVED TRACK—VII*

By the late S. R. M. PORTER, M.A., A.M.I.Mech.E., A.M.I.Loco.E.

Appendix V—Example : Calculation of flange forces, &c., for a 2-6-4 tank locomotive, passing round a 40-chain curve

This example has been chosen for its complexity, and represents the worst case likely to come before the ordinary designer. It is hoped that no one will be deterred by the apparent length of this example, from using this method of calculation.

For one thing, the whole example has been worked out twice, once based on the sliding hypothesis, and once on the creep hypothesis. Secondly, although very little experience of such calculations would indicate that the main truck is likely to adopt constrained curving in the present case, the writer has gone through the complete free curving calculation and proved it impossible, before proceeding with constrained curving, in order to make the example more complete. Third, several special cases have been included.

All figures have been worked out to slide rule accuracy only.

Conditions.—A 2-6-4 tank engine, whose relevant dimensions are shown on the diagram (Fig. 37) is passing round a

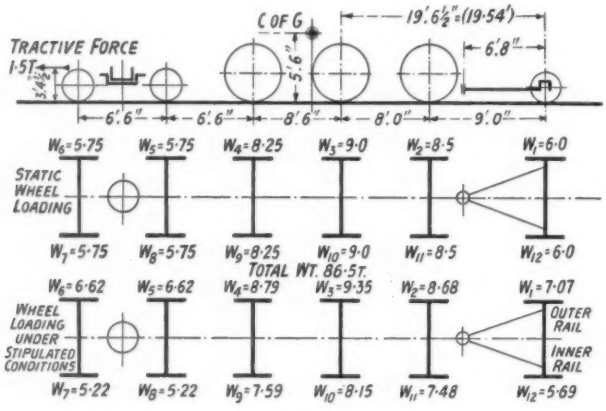


Fig. 37

40-chain curve, superelevated 3 in., at a speed of 60 m.p.h., exerting a tractive effort of 1·5 tons. To determine the flange forces, &c., set up :—

The weight of the pony truck is 2·75 tons, and of the bogie truck 5·98 tons (hence weight of main truck = 77·77 tons, by difference).

The stiffnesses of the springs are given in Table 2 :—

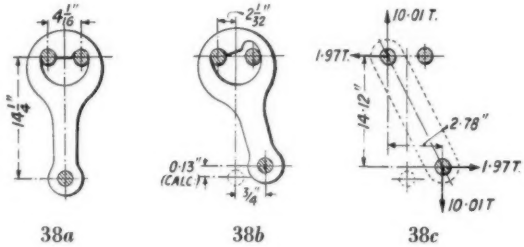
Spring :	Bogie Control	Bogie Bearing	Main Bearing	Pony Bearing
Number	2	4	6	2
Stiffness σ (in./ton)	5·00	0·118	0·139	0·120
Initial compression (in.)	$4\frac{15}{16}$"	—	—	—

TABLE 2

The dimensions of the pony swing links are as shown (Fig. 38A).

Alteration of wheel loading.—Let the centre of friction of the main truck be temporarily assumed to be 3 ft. in front of the trailing coupled axle ; then pony truck deflection can be shown to be $\frac{3}{4}$ in. approximately (Fig. 39), and compression of pony bearing springs, due to inclination of swing links, is $\delta = 0·13$ in. approximately (Fig. 38B.) This corresponds to an added load on the pony axle $\frac{2\delta}{\sigma} = \frac{2 \times 0·13}{0·120} = 2·16$ tons.

To maintain the locomotive in equilibrium, a load of 2·16 tons must be subtracted at the centre of gravity (distributed over all axles, according to the spring stiffnesses), and a rearing couple 2·16 × 19·54 (Fig. 37) = 42·21 ft.-tons, must be added. There is a further rearing couple, due to the



38a *38b* *38c*

tractive effort, 1·5 tons, acting 3·375 ft. above rail level = 5·06 ft.-tons. Hence total rearing couple = 47·27 ft.-tons.

There is also an overturning couple, due to the effects of centrifugal force and superelevation of the track, $\mathbf{W}h\left(\frac{v^2}{Rg} - \frac{e}{s}\right)$ (see part II*) $= 86·5 \times 5·5\left(\frac{88 \times 88}{2640 \times 32·2} - \frac{0·25}{4·92}\right) = 19·18$ ft.-tons. This causes a transfer of load from the inner to the outer rail of $\frac{19·18}{4·92} = 3·89$ tons (distributed over all axles).

By a simple calculation it is then shown that the main frame is raised 0·084 in. at the pony axle, and depressed 0·020 in. at the bogie centre, due to the rearing couple ; and depressed 0·083 in. at the outer wheels and raised 0·083 in. at the inner wheels, due to the overturning couple. The corresponding alteration in wheel loading is shown on the diagram (Fig. 37).

Known forces, &c.—The outward force, acting on each truck at its centre of gravity, due to effects of centrifugal force and superelevation of track, is $S = \mathbf{W}\left(\frac{v^2}{Rg} - \frac{e}{s}\right)$, where $\mathbf{W}$ is the weight of the truck.

Then, for { pony truck $S_A = 0·11$ tons. main truck $S = 3·13$ tons. bogie truck $S_B = 0·24$ tons.

Fig. 39

The centres of gravity of the pony and bogie trucks may be taken at the midpoints of their wheelbases ; from the weights of the trucks, it can be shown that the centre of gravity of the main truck lies 6·50 ft. in front of the trailing coupled axle.

* See editorial article on page 225.

* Page 257 of *The Railway Engineer*, August, 1934.

The side controlling force at the pony truck provided by the sideways component of the load transferred along the inclined swing links from the main truck, may be calculated as follows :—

Load transferred = sum of pony wheel loads, less weight of pony truck = (7·07 + 5·69) − 2·75 = 10·01 tons.

Then for equilibrium (Fig. 38c) we get (10·01 × 2·781) = (B_A × 14·12) ; from which B_A = 1·97 tons.

The side controlling force at the bogie truck, B_B, may be anything from zero up to the load corresponding to the initial compression of the check springs (= 1·97 tons), as long as the bogie centre is undeflected. If the centre be deflected γ in., then $B_B = (1·97 + 0·4\ \gamma)$ tons ..... (1)

Friction at the bogie centre has been neglected, as it may either assist or oppose the check springs.

Example No. 1, *using sliding hypothesis free curving for main truck.*—For determination of the partially known forces, assume the centre of friction of the main truck to be 3 ft. in front of the trailing coupled axle, and the centre of friction of the bogie truck to lie on the trailing bogie axle (Fig. 39). Then the centre of friction of the pony truck (which must adopt constrained curving) is calculated to be 1·803 ft. in front of the pony axle.

The deflection of the bogie truck is $\frac{1}{32}$ in. (Fig. 39), corresponding to a force B_B = 1·98 tons (from equation 1).

The first calculation is for the pony truck, which gives the reaction at the pivot centre, K, acting on the main truck. Let origin O_A be 1·803 ft. in front of pony axle, and 0·5 ft. from locomotive centre line (Fig. 40). Draw up a table as in Appendix I (Table 3).

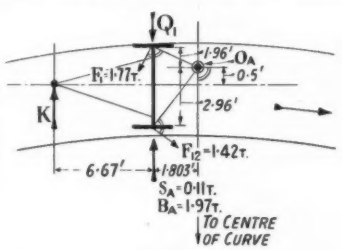


Fig. 40

Wheel	A	B	C	D	E	F	G	H
1	− 1·803	1·96	− 3·535	3·25	3·84	7·09	2·66	18·80
12	− 1·803	− 2·96	5·34	3·25	8·76	12·01	3·47	41·65

TABLE 3

From Appendix I, first equation is

$$\Sigma T = \Sigma \mu W \left\{ -\left(\frac{B}{G}\right) + \left(\frac{D}{H}\right) y \right\}$$

$$\therefore O = 1·77 \left(-\frac{1·96}{2·66} + \frac{3·25}{18·80} y_a \right) + 1·42 \left(\frac{2·96}{3·47} + \frac{3·25}{41·65} y_a \right)$$

This gives, y_a = 0·223 ft. Hence, centre of friction M_A is 1·803 ft. in front of the pony axle, and 0·723 ft. from locomotive centre line. This is sufficiently near to origin O_A not to require checking.

To find Q_1 and K draw out a further table, with origin at centre of friction M_A (Table 4).

Wheel	u'	v'	u'^2	v'^2	$(v'^2 + u'^2)$	$(v'^2 + u'^2)^{\frac{1}{2}}$
1	− 1·803	1·737	3·25	3·02	6·27	2·503
12	− 1·803	− 3·183	3·25	10·12	13·37	3·66

TABLE 4

From Appendix I, second equation is

$$\Sigma P + Q_1 - K = \Sigma \mu W \left\{ \frac{u'}{(v'^2 + u'^2)^{\frac{1}{2}}} \right\}$$

$$\therefore (-1·97 - 0·11) + Q_1 - K = 1·77 \left(\frac{-1·803}{2·503} \right) + 1·42 \left(\frac{-1·803}{3·66} \right).$$

This gives, $Q_1 - K = 0·105$ ..... (2)

Similarly, third equation is

$\Sigma P.a + \Sigma T.b - Q_1.u_1 + K.u_a = \Sigma \mu W (v'^2 + u'^2)^{\frac{1}{2}}$.

$\therefore$ 1·97 (1·803) + 0·11 (1·803) − 1·803 . Q_1 + 8·473 . K = 1·77 (2·503) + 1·42 (3·66).

This gives, $Q_1 - 4·70 . K = -3·26$..... (3)

From equations 2 and 3, we get, Q_1 = 1·01 tons, and K = 0·91 tons.

The next calculation is for the main truck, which adopts free curving. Let origin 0 be 3 ft. in front of the trailing coupled

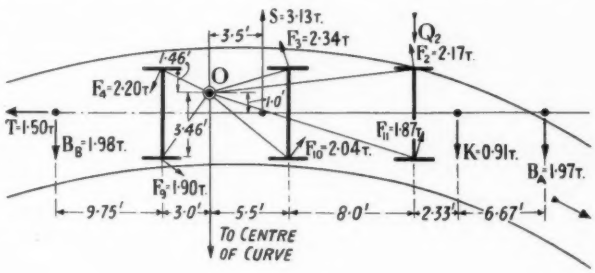


Fig. 41

axle, and 1 ft. from locomotive centre line (Fig. 41). Draw up a table as in Appendix I (Table 5).

Wheel	A	B	C	D	E	F	G	H
2	13·5	1·46	19·70	182·3	2·13	184·4	13·59	2,503·0
3	5·5	1·46	8·03	30·25	2·13	32·38	5·69	184·1
4	− 3·0	− 1·46	− 4·38	9·0	2·13	11·13	3·34	37·15
9	− 3·0	− 3·46	10·38	9·0	11·97	20·97	4·57	96·1
10	5·5	− 3·46	− 19·03	30·25	11·97	42·22	6·50	274·2
11	13·5	− 3·46	− 46·7	182·3	11·97	194·3	13·93	2,710·0

TABLE 5

From Appendix I, first equation is

$$\Sigma T = \Sigma \mu W \left\{ -\left(\frac{B}{G}\right) + \left(\frac{D}{H}\right) y - \left(\frac{C}{H}\right) x \right\}$$

$$\therefore 1·5 = 2·17 \left(-\frac{1·46}{13·59} + \frac{182·3}{2,503} y - \frac{19·70}{2,503} x \right) + 2·34 \left(-\frac{1·46}{5·69} + \frac{30·25}{184·1} y - \frac{8·03}{184·1} x \right) + 2·20 \left(-\frac{1·46}{3·34} + \frac{9·0}{37·15} y + \frac{4·38}{37·15} x \right) + 1·90 \left(\frac{3·46}{4·57} + \frac{9·0}{96·1} y - \frac{10·38}{96·1} x \right) + 2·04 \left(\frac{3·46}{6·50} + \frac{30·25}{274·2} y + \frac{19·03}{274·2} x \right) + 1·87 \left(\frac{3·46}{13·93} + \frac{182·3}{2,710} y + \frac{46·7}{2,710} x \right)$$

This gives, $0·308 = 1·602\ y + 0·109\ x$ ..... (4)

Similarly, second equation is

$$\Sigma P + Q_2 = \Sigma \mu W \left\{ \left(\frac{A}{G}\right) + \left(\frac{C}{H}\right) y - \left(\frac{E}{H}\right) x \right\}$$

$$\therefore (1·97 + 0·91 - 3·13 + 1·98) + Q_2 = 2·17 \left(\frac{13·5}{13·59} + \frac{19·70}{2,503} y - \frac{2·13}{2,503} x \right) + 2·34 \left(\frac{5·5}{5·69} + \frac{8·03}{184·1} y - \frac{2·13}{184·1} x \right) + 2·20 \left(-\frac{3·0}{3·34} - \frac{4·38}{37·15} y - \frac{2·13}{37·15} x \right) + 1·90 \left(-\frac{3·0}{4·57} + \frac{10·38}{96·1} y - \frac{11·97}{96·1} x \right) + 2·04 \left(\frac{5·5}{6·50} - \frac{19·03}{274·2} y - \frac{11·97}{274·2} x \right) + 1·87 \left(\frac{13·5}{13·93} - \frac{46·7}{2,710} y - \frac{11·97}{2,710} x \right)$$

This gives, $Q_2 - 3{\cdot}00 = -0{\cdot}109\,y - 0{\cdot}489\,x$ ..... (5)

Finally, third equation is

$$\Sigma P.a + \Sigma T.b + Q_2.u_2 = \Sigma\mu W\ \{G\}.$$

$$\therefore\ 1{\cdot}97\ (22{\cdot}5) + 0{\cdot}91\ (15{\cdot}83) - 3{\cdot}13\ (3{\cdot}5) - 1{\cdot}98\ (12{\cdot}75) + 1{\cdot}5\ (1{\cdot}0) + 13{\cdot}5\ .\ Q_2 = 2{\cdot}17\ (13{\cdot}59) + 2{\cdot}34\ (5{\cdot}69) + 2{\cdot}20\ (3{\cdot}34) + 1{\cdot}90\ (4{\cdot}57) + 2{\cdot}04\ (6{\cdot}50) + 1{\cdot}87\ (13{\cdot}93).$$

This gives $Q_2 = 5{\cdot}48$ tons.

Substituting in equation 5, we get

$$2{\cdot}48 = -0{\cdot}109\,y - 0{\cdot}489\,x \quad \text{.....} \quad (6)$$

also $0{\cdot}308 = 1{\cdot}602\,y + 0{\cdot}109\,x$ ..... (4)

From these two equations, we get $x = -5{\cdot}19$ ft., and $y = 0{\cdot}54$ ft.

Hence, centre of friction M is 2·19 ft. *behind* the trailing coupled axle, and 1·54 ft. from locomotive centre line. A distance of 5·2 ft. from origin to centre of friction is so large that a recalculation is advisable, from a new origin (see part VI*) ; and a case where the origin and centre of friction are on opposite sides of an axle, as here, makes a recalculation imperative.

Before doing so, however, the position of the locomotive on the curve, corresponding to the new centre of friction,

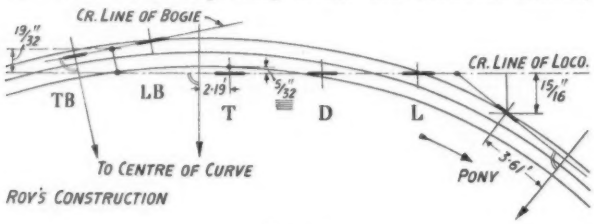


Fig. 42

should be examined (Fig. 42). The deflection of the pony truck is now $\frac{15}{16}$ in., with a centre of friction 3·61 ft. in front of the pony axle. This alters the pony controlling force, and (due to the inclination of the swing links) also the distribution of the wheel load along the engine. The deflection of the bogie truck, moreover, is now $-\frac{19}{32}$ in., the deflection being in the opposite direction to the bogie controlling force. This constitutes an impossible position of the locomotive on the track (see part II†), and indicates that the main truck must adopt constrained curving, not free curving.

(*Note*.—It would be useless to reverse the direction of the bogie controlling force B_B, and then recalculate for free curving, for this merely moves the centre of friction forward again, and gives a positive bogie deflection with a negative controlling force, equally an impossibility.)

Further, assuming a track true to gauge, and A.R.L.E. Class A flanges on leading and trailing coupled wheels, the formula (see Appendix III) for determining whether free curving is possible, is

$$c = (\epsilon_2 + \epsilon_9) - \left(\frac{u^2{}_2 - u^2{}_9}{2R}\right)$$

$$\therefore\ c = \left(\frac{5}{16} + \frac{5}{16}\right) - \left\{\frac{(18{\cdot}69 \times 12)^2 - (2{\cdot}19 \times 12)^2}{2 \times 2{,}640 + 12}\right\} \text{ in.}$$

This gives $c = -\frac{5}{32}$ in.

With the calculated centre of friction, the inner trailing coupled wheel would be running $\frac{5}{32}$ in. inside the rail head. This is again an impossibility, and shows that constrained curving must be adopted.

Constrained curving for main truck.—In the normal type of constrained curving, the wheel flange in contact with the rails would be the outer leading and inner trailing coupled. The position of the corresponding centre of friction, with the same track clearances as before, is given by the formula (see Appendix III)

$$u_9 = \frac{R}{l}(\epsilon_2 + \epsilon_9) - \frac{l.}{2}$$

$$\therefore\ u_9 = \frac{2{,}640}{16{\cdot}5} \cdot \frac{1}{12}\left(\frac{5}{16} + \frac{5}{16}\right) - \frac{16{\cdot}5}{2} \text{ ft.}$$

This gives $u_9 = 0{\cdot}083$ ft., *i.e.*, the centre of friction would be 1 in. behind the trailing coupled axle.

It should be noted, however, that the deflection of the bogie truck in this position is still a minus quantity, $= -\frac{11}{32}$ in., corresponding to a controlling force of 2·11 tons acting *outwards* ; and this might be sufficient to pull the inner trailing coupled wheel flange away from the rail.

Consideration should therefore be given to another possibility, namely, that the constrained curving may be determined by the leading coupled wheel flange and the position of the undeflected bogie centre. The two unknown forces then are : Q_2 the flange force at the outer leading coupled wheel, and B_B the bogie controlling force. If a calculation be made on this basis, and B_B falls between + 1·97 tons and − 1·97 tons, no impossibility arises, and this special sort of constrained curving will take place.

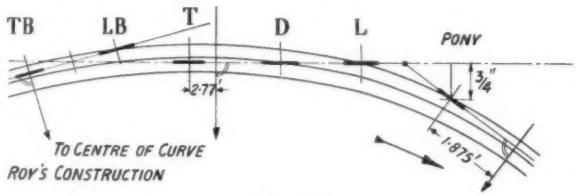


Fig. 43

The position of the centre of friction of the main truck in this case (Fig. 43) is 2·77 ft. in front of the trailing coupled axle ; the deflection of the pony truck is $\frac{3}{4}$ in., with a centre of friction 1·875 ft. in front of the pony axle. This is sufficiently near to the figures previously obtained not to require recalculation (see p. 233).

For the main truck, let origin O be 2·77 ft. in front of trailing

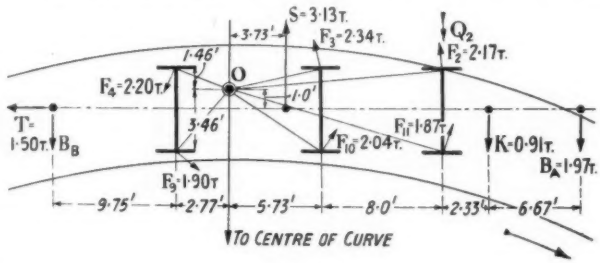


Fig. 44

coupled axle, and 1 ft. from locomotive centre line (Fig. 44). Draw out a table as in Appendix I (Table 6).

Wheel	A	B	C	D	E	F	G	H
2	13·73	1·46	20·05	188·7	2·13	190·8	13·81	2,635·0
3	5·73	1·46	8·37	32·85	2·13	34·98	5·92	207·0
4	− 2·77	1·46	− 4·05	7·68	2·13	9·81	3·13	30·75
9	− 2·77	− 3·46	9·58	7·68	11·97	19·65	4·43	87·2
10	5·73	− 3·46	− 19·81	32·85	11·97	44·82	6·70	300·0
11	13·73	− 3·46	− 47·5	188·7	11·97	200·7	14·17	2,845·0

TABLE 6

From Appendix I, first equation is

$$\Sigma T = \Sigma\mu W\left\{-\left(\frac{B}{G}\right) + \left(\frac{D}{H}\right)y\right\}$$

$$\therefore\ 1{\cdot}5 = 2{\cdot}17\left(-\frac{1{\cdot}46}{13{\cdot}81} + \frac{188{\cdot}7}{2{,}635}\,y\right) + 2{\cdot}34\left(-\frac{1{\cdot}46}{5{\cdot}92} + \frac{32{\cdot}85}{207}\,y\right) + 2{\cdot}20\left(-\frac{1{\cdot}46}{3{\cdot}13} + \frac{7{\cdot}68}{30{\cdot}75}\,y\right) + 1{\cdot}90\left(\frac{3{\cdot}46}{4{\cdot}43} + \frac{7{\cdot}68}{87{\cdot}2}\,y\right) + 2{\cdot}04\left(\frac{3{\cdot}46}{6{\cdot}70} + \frac{32{\cdot}85}{300}\,y\right) + 1{\cdot}87\left(\frac{3{\cdot}46}{14{\cdot}17} + \frac{188{\cdot}7}{2{,}845}\,y\right)$$

This gives $y = 0{\cdot}214$ ft.

* Page 424 of *The Railway Engineer*, January, 1935.
† Page 256 of *The Railway Engineer*, August, 1934.

Hence, centre of friction M is 2·77 ft. in front of the trailing coupled axle, and 1·21 ft. from locomotive centre line.

To find Q_2 and B_B, draw up a further table, taking the origin at the centre of friction (Table 7).

Wheel	u'	v'	u'^2	v'^2	$(v'^2 + u'^2)$	$(v'^2 + u'^2)^{\frac{1}{2}}$
2	13·73	1·25	188·7	1·56	190·3	13·80
3	5·73	1·25	32·85	1·56	34·41	5·86
4	− 2·77	1·25	7·68	1·56	9·24	3·04
9	− 2·77	− 3·67	7·68	13·47	21·15	4·59
10	5·73	− 3·67	32·85	13·47	46·32	6·80
11	13·73	− 3·67	188·7	13·47	202·2	14·22

TABLE 7

From Appendix I, second equation is

$$\Sigma P + Q_2 + B_B = \Sigma \mu W \left\{ \frac{u'}{(v'^2 + u'^2)^{\frac{1}{2}}} \right\}$$

$$\therefore (1·97 + 0·91 - 3·13) + Q_2 + B_B = 2·17 \left(\frac{13·73}{13·80}\right) + 2·34 \left(\frac{5·73}{5·86}\right) - 2·20 \left(\frac{2·77}{3·04}\right) - 1·90 \left(\frac{2·77}{4·59}\right) + 2·04 \left(\frac{5·73}{6·80}\right) + 1·87 \left(\frac{31·73}{14·22}\right)$$

This gives $Q_2 + B_B = 5·08$ ..... (7)

Also, third equation is

$$\Sigma P.a + \Sigma T.b + Q_2.u_2 - B_B.a_b = \Sigma \mu W (v'^2 + u'^2)^{\frac{1}{2}}.$$

$$\therefore 1·97\ (22·73) + 0·91\ (16·06) - 3·13\ (3·73) + 1·5\ (1·21) + 13·73\ .\ Q_2 - 12·52\ .\ B_B = 2·17\ (13·80) + 2·34\ (5·86) + 2·20\ (3·04) + 1·90\ (4·59) + 2·04\ (6·80) + 1·87\ (14·22).$$

This gives $Q_2 - 0·912\ .\ B_B = 3·65$ ..... (8)

From equations 7 and 8, we get, $Q_2 = 4·33$ tons, and $B_B = 0·75$ tons.

As B_B lies between + 1·97 and − 1·97 tons, the form of constrained curving that we have assumed will take place.

It now remains to make a calculation for the bogie truck, which adopts free curving. As the wheel loads on the two sides of the bogie are not equal, there will be two centres of friction, one for the leading pair of wheels M_L, and one for the trailing pair M_T (see part III*). Let origin O_L for the leading pair be 0·1 ft. behind the trailing bogie axle, and 0·3 ft. from locomotive centre line (Fig. 45); let origin O_T for the trailing

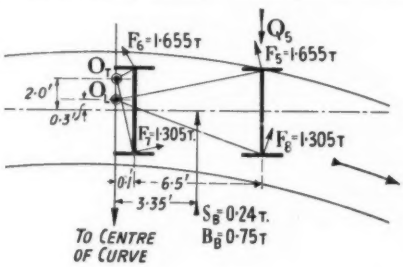


Fig. 45

pair be 0·1 ft. behind the trailing bogie axle, and 2 ft. from locomotive centre line. Draw up two tables (one for each pair of wheels, Table 8).

Wheel	A	B	C	D	E	F	G	H
				Leading				
5	6·6	2·16	14·25	43·56	4·67	48·23	6·94	335·0
8	6·6	− 2·76	− 18·21	43·56	7·62	51·18	7·16	366·0
				Trailing				
6	0·1	0·46	0·046	0·01	0·212	0·222	0·471	0·105
7	0·1	− 4·46	− 0·446	0·01	19·89	19·90	4·46	78·8

TABLE 8

* Page 285 of *The Railway Engineer*, September, 1934.

For the leading wheels, first equation is

$$\Sigma T = \Sigma \mu W \left\{ -\left(\frac{B}{G}\right) + \left(\frac{D}{H}\right) y_L - \left(\frac{C}{H}\right) x_b \right\}$$

$$\therefore O = 1·655 \left(-\frac{2·16}{6·94} + \frac{43·56}{335} y_L - \frac{14·25}{335} x_b \right) + 1·305 \left(\frac{2·76}{7·16} + \frac{43·56}{366} y_L + \frac{18·21}{366} x_b \right)$$

This gives, $O = - 0·011 + 0·370\ y_L - 0·0054\ x_b$ .... (9)

For the trailing wheels, first equation is

$$\Sigma T = \Sigma \mu W \left\{ -\left(\frac{B}{G}\right) + \left(\frac{D}{H}\right) y_T - \left(\frac{C}{H}\right) x_b \right\}$$

$$\therefore O = 1·655 \left(-\frac{0·46}{0·471} + \frac{0·01}{0·105} y_T - \frac{0·046}{0·105} x_b \right) + 1·305 \left(\frac{4·46}{4·46} + \frac{0·01}{78·8} y_T + \frac{0·446}{78·8} x_b \right)$$

This gives $0 = - 0·313 + 0·158\ y_T - 0·721\ x_b$ ..... (10)

Also, for both pairs of wheels together, second equation is

$$\Sigma P + Q_5 = \Sigma \mu W \left\{ \left(\frac{A}{G}\right) + \left(\frac{C}{H}\right) y - \left(\frac{E}{H}\right) x_b \right\}$$

$$\therefore (- 0·75 - 0·24) + Q_5 = 1·655 \left(\frac{6·6}{6·94} + \frac{14·25}{335} y_L - \frac{4·67}{335} x_b \right) + 1·305 \left(\frac{6·6}{7·16} - \frac{18·21}{366} y_L - \frac{7·62}{366} x_b \right) + 1·655 \left(\frac{0·1}{0·471} + \frac{0·046}{0·105} y_T - \frac{0·212}{0·105} x_b \right) + 1·305 \left(\frac{0·1}{4·46} - \frac{0·446}{78·8} y_T - \frac{19·89}{78·8} x_b \right)$$

This gives, $Q_5 = 4·15 + 0·0054\ y_L + 0·721\ y_T - 3·74\ x_b$ .. (11)

The third equation refers to moments about the origin, and in this case there are two origins, O_L and O_T. It is therefore necessary to take moments about some other point; and the point where the perpendicular through the origins cuts the centre line of the truck is the most convenient. It can be shown that the appropriate formula is $\Sigma P.a + Q_5.u_5 = \Sigma \mu W \{G\}$, provided that $\Sigma T = 0$ (as in this case).

$$\therefore - 0·75\ (3·35) - 0·24\ (3·35) + 6·60\ .\ Q_5 = 1·655\ (6·94) + 1·305\ (7·16) + 1·655\ (0·471) + 1·305\ (4·46).$$

This gives $Q_5 = 4·67$ tons.

Substituting in equation 11, we get

$$0·520 = 0·0054\ y_L + 0·721\ y_T - 3·74\ x_b \quad \ldots\ldots (12)$$

also $0·011 = 0·370\ y_L - 0·0054\ x_b$ ..... (9)

and $0·313 = 0·158\ y_T - 0·721\ x_b$ ..... (10)

From these three equations, we get $x_b = 2·00$ ft., $y_L = 0·06$ ft., and $y_T = 11·10$ ft.

Now, for one thing, this value of x_b brings the centres of friction in front of the trailing axle, which means that the calculation will have to be done again (see p. 234). Further the value of y_T brings the centre of friction for the trailing wheels outside the rail gauge, which means that the frictional forces at both wheels act in a forward direction, and provide a tractive force, although no tractive force is to be exerted by the bogie wheels. This is a contradiction in terms, and it can only be assumed that the construction has broken down.

The reason for this is that x and y are *not* small compared with u and v (*e.g.*, $x = 2·00$, $u_6 = 0·1$), so that the approximations on which the calculation is based do not hold (see footnote, part VI*). This is always likely to occur when the centre of friction comes very near to an axle.

There are then two alternatives. If the centre of friction is just off the axle centre line, it is necessary to try again and again with different origins, until one is found so near to the actual centre of friction (x) that the adjacent axle is comparatively far off (u), in which case alone the calculations will give a reasonable answer.

If, however, the centre of friction is on the axle centre line, no amount of trial will give a suitable origin; for as $x = u$, therefore x can never be small compared with u. It is thus a good rule, if the centre of friction appears to come near an axle, to try it at the axle.

To return to the trailing bogie of the 2-6-4 tank engine.

* Page 424 of *The Railway Engineer*, January 1935.

Assuming the centres of friction to lie on the trailing axle, the distance of M_L from the centre line of the locomotive (y_L) can easily be calculated ; in the present example, $y_L = 0{\cdot}33$ ft. But the distance of M_L from the centre line of the locomotive (y_T) cannot be so easily settled, for no amount of movement of M_T along the axle will alter the directions of the frictional forces (forward and backward, see Fig. 46), and so make the forward component of one frictional force equal to the backward component of the other (corresponding to first equation of motion, $\Sigma T = O$).

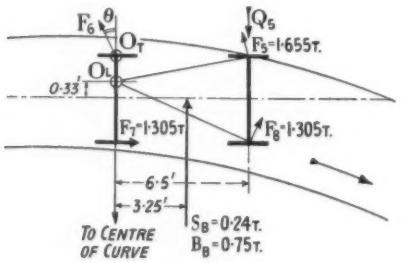
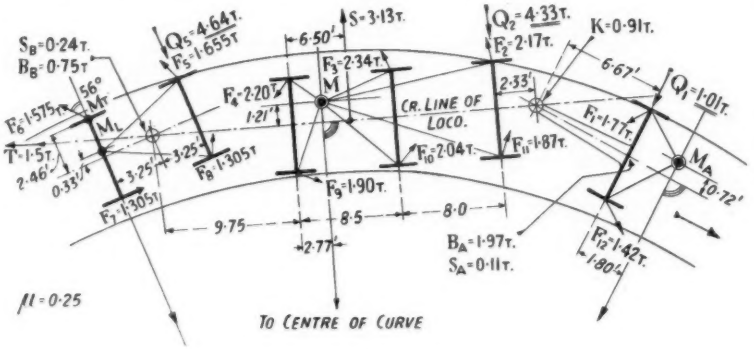


Fig. 46 and (right) Fig. 47



The centre of friction M_T must then be placed at the actual point of contact of the outer trailing bogie wheel, which therefore undergoes pure rolling, without slip. The frictional force F_6 at this wheel can now have any magnitude from O to μW_6 (*i.e.*, 0 to 1·655 tons), and can act in any direction. Let the backward component $= F_6 \sin \theta_6$, and the outward component $= F_6 \cos \theta_6$.

First equation then is $\Sigma T = \mu W_7 - F_6 \sin \theta_6$.

$\therefore F_6 \sin \theta_6 = 1{\cdot}305$ ..... (13)

For both pairs of wheels together, second equation is (Fig. 46)

$$\Sigma P + Q_5 = \mu W_5 \cdot \frac{u_5}{d_5} + F_6 \cos \theta_6 + 0 + \mu W_8 \cdot \frac{u_8}{d_8}$$

$$\therefore (-0{\cdot}75 - 0{\cdot}24) + Q_5 = 1{\cdot}655 \left(\frac{6{\cdot}50}{6{\cdot}84}\right) + F_6 \cos \theta_6 + 1{\cdot}305 \cdot \left(\frac{6{\cdot}50}{7{\cdot}08}\right)$$

This gives $Q_5 - F_6 \cos \theta_6 = 3{\cdot}76$ ..... (14)

For third equation, take moments about M_L.

Then

$\Sigma P.a + \Sigma T.b + Q_5.u_5 = \mu W_5.d_5 + F_6.s \sin \theta_6 + \mu W_8.d_8$.

$\therefore -0{\cdot}75\ (3{\cdot}25) - 0{\cdot}24\ (3{\cdot}25) + 6{\cdot}50.Q_5 = 1{\cdot}655\ (6{\cdot}84) + 1{\cdot}305\ (4{\cdot}92) + 1{\cdot}305\ (7{\cdot}08)$.

This gives $Q_5 = 4{\cdot}64$ tons.

Substituting in equation 14, we get

$F_6 \cos \theta_6 = 0{\cdot}88$ ..... (15)

also

$F_6 \sin \theta_6 = 1{\cdot}305$ ..... (13)

From these equations, we get $F_6 = 1{\cdot}575$ tons (which is between O and 1·655), at an angle $\theta_6 = 56°$ to the bogie axle.

All the flange forces acting on the 2-6-4 tank engine have now been determined, on the sliding hypothesis ; and these, together with the positions of the centres of friction for the different trucks, are shown in the diagram (Fig. 47).

Example No. 2, using creep hypothesis free for curving main truck.—We may make the same preliminary assumptions as in example No. 1, *i.e.*, pony controlling force $B_A = 1{\cdot}97$ tons, and bogie controlling force $B_B = 1{\cdot}98$ tons.

The first calculation is for the pony truck, which gives the reaction at the pivot centre K, acting on the main truck. Let origin O_A be at the midpoint of the pony axle.

From Appendix II, first equation is $\Sigma T = -\frac{k}{R} \cdot \Sigma W\ (v - y)$.

$$\therefore O = -\frac{10}{2{,}640} \left\{7{\cdot}07\ (2{\cdot}46 - y_a) + 5{\cdot}69\ (-2{\cdot}46 - y_a)\right\}$$

This gives, $y_a = 0{\cdot}266$ ft. Hence centre of friction M_A is 1·803 ft. in front of the pony axle, and 0·266 ft. from locomotive centre line. Take a new origin at centre of friction M_A (Fig. 48).

From Appendix II, second equation is

$$\Sigma P + Q_1 - K = \frac{k}{R} \cdot \Sigma W\ .\ u'.$$

$$\therefore (-1{\cdot}97 - 0{\cdot}11) + Q_1 - K = \frac{10}{2{,}640} \left\{7{\cdot}07\ (-1{\cdot}803) + 5{\cdot}69\ (-1{\cdot}803)\right\}.$$

This gives, $Q_1 - K = 1{\cdot}955$ ..... (16)

Similarly, third equation is

$$\Sigma P.a + \Sigma T.b - Q_1.u_1 + K.u_o = \frac{k}{R}\ \Sigma W\ (v'^2 + u'^2).$$

$$\therefore 1{\cdot}97\ (1{\cdot}803) + 0{\cdot}11\ (1{\cdot}803) - 1{\cdot}803.Q_1 + 8{\cdot}473.K = \frac{10}{2{,}640} \left\{7{\cdot}07\ (2{\cdot}194^2 + 1{\cdot}803^2) + 5{\cdot}69\ (2{\cdot}726^2 + 1{\cdot}803^2)\right\}$$

This gives, $Q_1 - 4{\cdot}70\ .\ K = 1{\cdot}836$ ..... (17)

From equations 16 and 17, we get, $Q_1 = 1{\cdot}99$ tons, and $K = 0{\cdot}03$ tons.

The next calculation is for the main truck, which adopts free curving. Let origin O be at the midpoint of the trailing coupled axle (Fig. 49).

From Appendix II, first equation is $\Sigma T = -\frac{k}{R} \Sigma W\ (v - y)$.

$$\therefore 1{\cdot}5 = -\frac{10}{2{,}640} \Big\{8{\cdot}68\ \ (2{\cdot}46 - y) + 9{\cdot}35\ \ (2{\cdot}46 - y) + 8{\cdot}79\ (2{\cdot}46 - y) + 7{\cdot}59\ (-2{\cdot}46 - y) + 8{\cdot}15\ (-2{\cdot}46 - y) + 7{\cdot}48\ (-2{\cdot}46 - y).$$

This gives, $y = 8{\cdot}09$ ft.

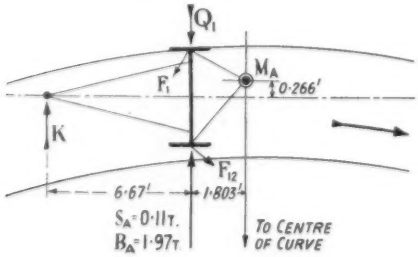


Fig. 48

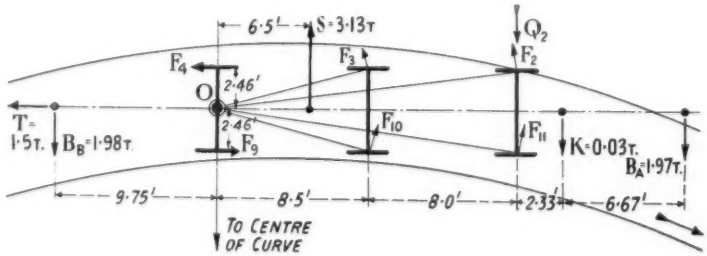


Fig. 49

Similarly, second equation is $\Sigma P + Q_2 = \frac{k}{R} \Sigma W\ (u - x)$.

$\therefore\ (1{\cdot}97 + 0{\cdot}03 - 3{\cdot}13 + 1{\cdot}98) + Q_2$

$= \frac{10}{2{,}640}\left\{8{\cdot}68\ (16{\cdot}5 - x) + 9{\cdot}35\ (8{\cdot}5 - x) + 8{\cdot}79\ (-x)\right.$

$\left. + 7{\cdot}59\ (-x) + 8{\cdot}15\ (8{\cdot}5 - x) + 7{\cdot}48\ (16{\cdot}5 - x)\right\}$.

This gives, $Q_2 = 0{\cdot}72 - 0{\cdot}189\ x$ ..... (18)

Finally, third equation is

$\Sigma P.a + \Sigma T.b + Q_2.u_2 = \frac{k}{R} \Sigma W\left\{(v^2 + u^2) - ux - vy\right\}$

$\therefore\ 1{\cdot}97\ (25{\cdot}5) + 0{\cdot}03\ (18{\cdot}83) - 3{\cdot}13\ (6{\cdot}5) - 1{\cdot}98)\ (9{\cdot}75) + 1{\cdot}5\ (0) + 16{\cdot}5\ .\ Q_2$

$= \frac{10}{2{,}640} . 8{\cdot}68\ (2{\cdot}46^2 + 16{\cdot}5^2 - 16{\cdot}5\ x - 2{\cdot}46\ y)$

$+ \frac{10}{2{,}640} . 9{\cdot}35\ (2{\cdot}46^2 + 8{\cdot}5^2 - 8{\cdot}5\ x - 2{\cdot}46\ y)$

$+ \frac{10}{2{,}640} . 8{\cdot}79\ (2{\cdot}46^2 + 0 - 0 - 2{\cdot}46\ y)$

$+ \frac{10}{2{,}640} . 7{\cdot}59\ (2{\cdot}46^2 + 0 - 0 + 2{\cdot}46\ y)$

$+ \frac{10}{2{,}640} . 8{\cdot}15\ (2{\cdot}46^2 + 8{\cdot}5^2 - 8{\cdot}5\ x + 2{\cdot}46\ y)$

$+ \frac{10}{2{,}640} . 7{\cdot}48\ (2{\cdot}46^2 + 16{\cdot}5^2 - 16{\cdot}5\ x + 2{\cdot}46\ y)$

Substituting $y = 8{\cdot}09$, this gives, $Q_2 = 0{\cdot}696 - 0{\cdot}095\ x$.. (19)

From equations 18 and 19, we get $Q_2 = 0{\cdot}67$ tons, and $x = 0{\cdot}26$ ft.

Hence, centre of friction M is 0·26 ft. in front of the trailing coupled axle, and 8·09 ft. from locomotive centre line. In this position, however, the deflection of the bogie truck is in the opposite direction to the controlling force exerted; this constitutes an impossible position of the locomotive, as before (see p. 234); and for the same reasons, we must consider the special form of constrained curving where the position of the main truck is determined by the leading coupled wheel flange, and the position of the undeflected bogie centre.

Constrained curving for main truck.—The position of the centre of friction is 2·77 ft. in front of the trailing coupled axle, and 8·09 ft. from locomotive centre line (since, on the creep hypothesis, the first equation of motion is the same, whatever motion the truck undergoes).

Let origin O be at the centre of friction (Fig. 50).

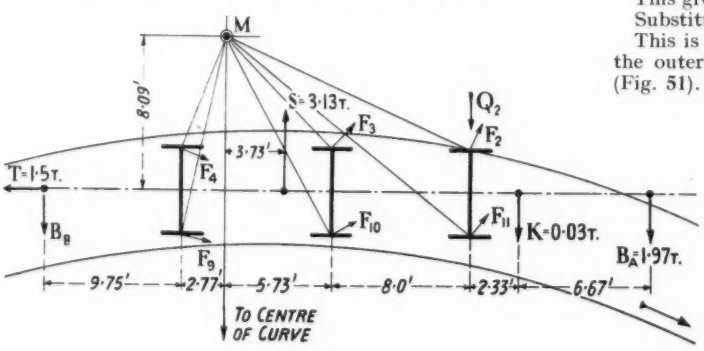


Fig. 50

From Appendix II, second equation is $\Sigma P + Q_2 + B_B = \frac{k}{R} \Sigma W\ .\ u'$.

$\therefore\ (1{\cdot}97 + 0{\cdot}03 - 3{\cdot}13) + Q_2 + B_B = \frac{10}{2{,}640}\left\{8{\cdot}68\ (13{\cdot}73) + 9{\cdot}35\ (5{\cdot}73) - 8{\cdot}79\ (2{\cdot}77) - 7{\cdot}59\ (2{\cdot}77) + 8{\cdot}15\ (5{\cdot}73) + 7{\cdot}48\ (13{\cdot}73)\right\}$.

This gives, $Q_2 + B_B = 2{\cdot}18$ ..... (20)

Similarly, third equation is

$\Sigma P.a + \Sigma T.b + Q_2.u_2 - B_B\ .\ a_b = \frac{k}{R}\ .\ \Sigma W\ (v'^2 + u'^2)$.

$\therefore\ 1{\cdot}97\ (22{\cdot}73) + 0{\cdot}03\ (16{\cdot}06) - 3{\cdot}13\ (3{\cdot}73) + 1{\cdot}5\ (8{\cdot}09) + 13{\cdot}73\ .\ Q_2 - 12{\cdot}52\ .\ B_B = \frac{10}{2{,}640}\left\{8{\cdot}68\ (5{\cdot}63^2 + 13{\cdot}73^2) + 9{\cdot}35\ (5{\cdot}63^2 + 5{\cdot}73^2) + 8{\cdot}79\ (5{\cdot}63^2 + 2{\cdot}77^2) + 7{\cdot}59\ (10{\cdot}55^2 + 2{\cdot}77^2) + 8{\cdot}15\ (10{\cdot}55^2 + 5{\cdot}73^2) + 7{\cdot}48\ (10{\cdot}55^2 + 13{\cdot}73^2)\right\}$.

This gives, $Q_2 - 0{\cdot}912\ .\ B_B = -1{\cdot}35$ ..... (21)

From equations 20 and 21, we get $Q_2 = 0{\cdot}33$ tons, and $B_B = 1{\cdot}85$ tons.

As B_B lies between + 1·97 and − 1·97 tons, the form of constrained curving that we have assumed will take place.

It now remains to make a calculation for the bogie truck, which adopts free curving. As the calculation involves no approximations, there will be no trouble if the centre of friction happens to be near an axle. Further, as the loads on the outer and inner wheels are in the same proportion on each bogie axle, the centres of friction M_L and M_T for the two bogie axles will coincide—this would not occur on the sliding hypothesis.

Let origin be at bogie centre.

From Appendix II, first equation for either pair of wheels is

$\Sigma T = -\frac{k}{R}\ .\ \Sigma W\ (v - y)$.

$\therefore\ O = -\frac{10}{2{,}640}\left\{6{\cdot}62\ (2{\cdot}46 - y_b) + 5{\cdot}22\ (-2{\cdot}46 - y_b)\right\}$

This gives, $y_b = 0{\cdot}29$ ft.

Similarly, second equation is $\Sigma P + Q_5 = \frac{k}{R}\ .\ \Sigma W\ (u - x)$.

$\therefore\ -1{\cdot}85 - 0{\cdot}24) + Q_5 = \frac{10}{2{,}640}\left\{6{\cdot}62\ (3{\cdot}25 - x_b) + 6{\cdot}62\ (-3{\cdot}25 - x_b) + 5{\cdot}22\ (-3{\cdot}25 - x_b) + 5{\cdot}22\ (3{\cdot}25 - x_b)\right\}$

This gives, $Q_5 = 2{\cdot}085 - 0{\cdot}090\ x_b$ ..... (22)

Finally, third equation is

$\Sigma P.a + \Sigma T.b + Q_5.u_5 = \frac{k}{R}\ .\ \Sigma W\left\{(v^2 + u^2) - ux - vy\right\}$

(in this case, $v^2 + u^2 = 2{\cdot}46^2 + 3{\cdot}25^2 = 16{\cdot}61$ for all wheels).

$\therefore\ 1{\cdot}85\ (0) + 0{\cdot}24\ (0) + 3{\cdot}25\ .\ Q_5 = \frac{10}{2{,}640}\left\{6{\cdot}62\ (16{\cdot}61 - 3{\cdot}25\ x_b - 2{\cdot}46 y_b) + 6{\cdot}62\ (16{\cdot}61 + 3{\cdot}25\ x_b - 2{\cdot}46 y_b) + 5{\cdot}22\ (16{\cdot}61 + 3{\cdot}25 x_b + 2{\cdot}46\ y_b) + 5{\cdot}22\ (16{\cdot}61 - 3{\cdot}25 x_b + 2{\cdot}46 y_b)\right\}$

This gives, $Q_5 = 0{\cdot}46$ tons.

Substituting in equation 22, we get $x_b = 18{\cdot}2$ ft.

This is an impossible position for the centre of friction, as the outer trailing wheel would come outside the outer rail (Fig. 51). The bogie must, therefore, adopt the special form

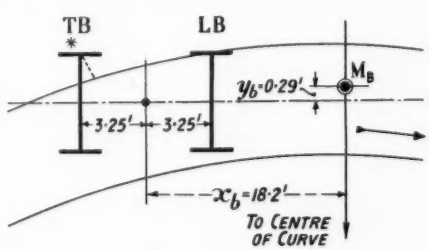


Fig. 51

of constrained curving in which both wheel flanges bear against the outer rail.

The position of the centre of friction M_B is then 3·25 ft. in front of the trailing bogie axle, and 0·29 ft. from locomotive centre line. Let origin be at centre of friction (Fig. 52).

From Appendix II, second equation is

$\Sigma P + Q_5 + Q_6 = \frac{k}{R}\ .\ \Sigma W\ .\ u'$.

$\therefore\ (-1{\cdot}85 - 0{\cdot}24) + Q_5 + Q_6 =$ (in this case) O.

This gives, $Q_5 + Q_6 = 2 \cdot 085$ ..... (23)

Similarly, third equation is

$$\Sigma P.a + \Sigma T.b + Q_5.u_5 + Q_6.u_6 = \frac{k}{R} \cdot \Sigma W\,(v'^2 + u'^2).$$

$$\therefore\ 1 \cdot 85\ (0) + 0 \cdot 24\ (0) + 3 \cdot 25 \cdot Q_5 - 3 \cdot 25 \cdot Q_6$$

$$= \frac{10}{2{,}640} \cdot 2 \left\{ 6 \cdot 62\ (2 \cdot 17^2 + 3 \cdot 25^2) + 5 \cdot 22\ (2 \cdot 75^2 + 3 \cdot 25^2) \right\}$$

This gives, $Q_5 - Q_6 = 0 \cdot 455$ ..... (24)

From equations 23 and 24, we get $Q_5 = 1 \cdot 27$ tons, and $Q_6 = 0 \cdot 77$ tons.

The new position taken up by the bogie affects the centre of friction of the main truck (since the position of the latter is determined by the position of the undeflected bogie centre). The alteration is, however, small, and it is unnecessary to rework the calculations for the main truck, as the following results of a reworked calculation will show :—

- $x = 3 \cdot 18$ ft. (instead of 2·77 ft.) in front of trailing coupled axle.
- $Q_2 = 0 \cdot 28$ tons (instead of 0·33 tons).
- $B_B = 1 \cdot 83$ tons (instead of 1·85 tons).

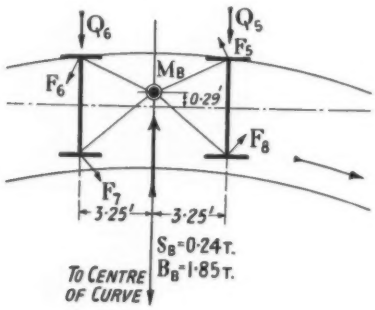


Fig. 52

All the flange forces acting on the 2-6-4 tank engine have now been determined, on the creep hypothesis; and these, together with the positions of the centres of friction for the different trucks, are shown in the diagram (Fig. 53).

Conclusions.—A comparison of Figs. 47 and 53 shows that the frictional forces at the treads of the wheels, calculated on the sliding hypothesis, are greater than the frictional forces, on the creep hypothesis; and in consequence the flange forces, on the sliding hypothesis, are greater than the flange forces, on the creep hypothesis, *except* at the pony truck wheels. In this case, the truck is inward running, so the frictional forces assist in the curving of the locomotive, and a reduction in frictional force means an increase of flange force—the reverse of what is normally to be expected.

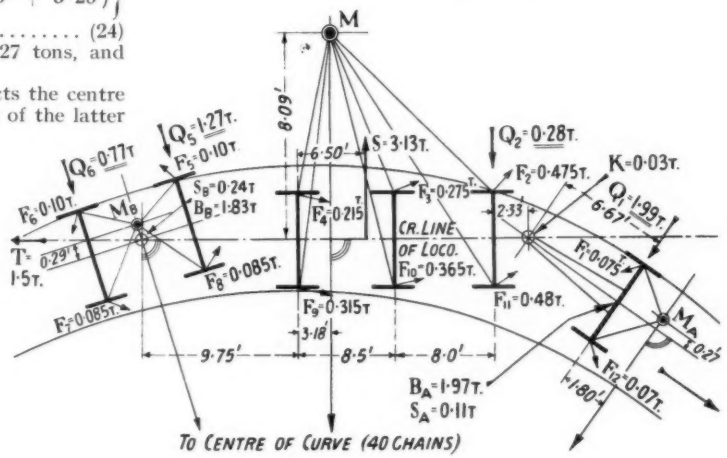


Fig. 53

L.N.E.R. yard at Niddrie West, Edinburgh, as recently illuminated by G.E.C. floodlights equipped with 500 watt Osram lamps

TURNING LOCOMOTIVES BY POWER FROM THE BRAKE APPARATUS

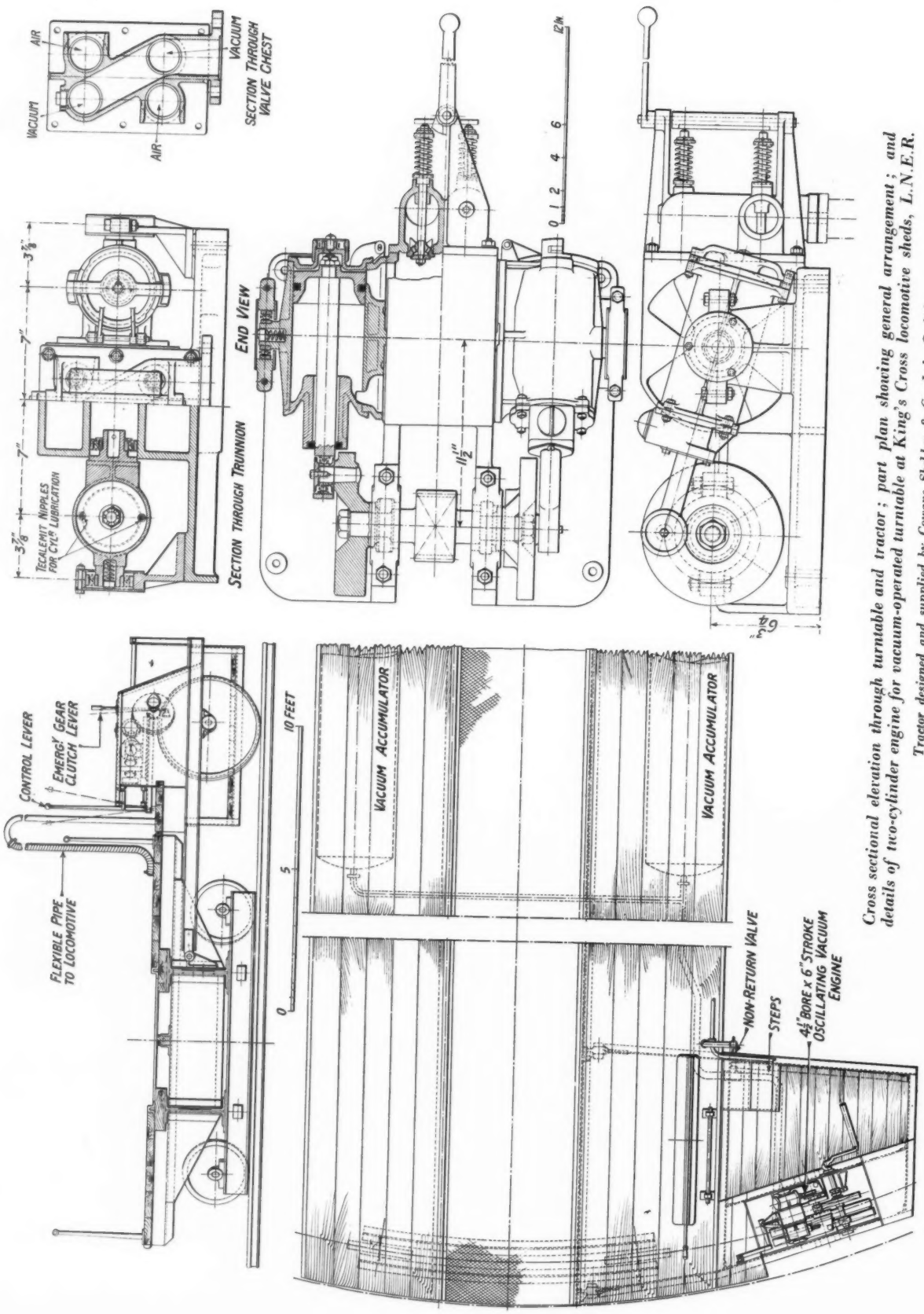
First application of a new patent system to a 70-ft. L.N.E.R. turntable at King's Cross

WITH the increase in weight and length of the largest types of locomotive employed in this country, a problem which had earlier called for solution abroad, where larger engines were in use, became manifest here. This is the difficulty of readily turning modern locomotives with the aid only of their crews. The locomotive has not merely to be run on to the table but must be stopped in just such a position as to balance over the table centre, and the attainment of this position may entail several to and fro movements of the engine. With the engine properly balanced the task of turning her when left to two men is not a light one; with the engine slightly off balance it is much increased. Turntables in which the actual turning is carried out by electric or other motor have already been tried here and are met with very frequently abroad, where special operations are employed. In all cases the practical desiderata are that the turning apparatus shall be robust, easily and cheaply operated by the engine crew, require no attention when not in use, and shall be applicable to all types of table without alteration to existing structures.

An apparatus which appears to fill these requirements in a marked degree has been recently applied to the 70-ft. turntable at the King's Cross locomotive running sheds of the L.N.E.R. This apparatus has been introduced and patented by Cowans Sheldon & Co. Ltd. and the accompanying photographs, specially taken for this article by permission of Mr. H. N. Gresley, C.B.E., Chief Mechanical Engineer, L.N.E.R., and the drawings, illustrate its features.

Briefly these consist of two double-acting oscillating cylinders, each 4½ in. diam. × 6 in. stroke running at 350 r.p.m. and driving a crankshaft on which a pinion meshes with gearing driving the wheel through which the

Turning an L.N.E.R. Pacific locomotive on the vacuum-operated turntable at King's Cross. The hose connection with the vacuum brake pipe of the engine is clearly seen



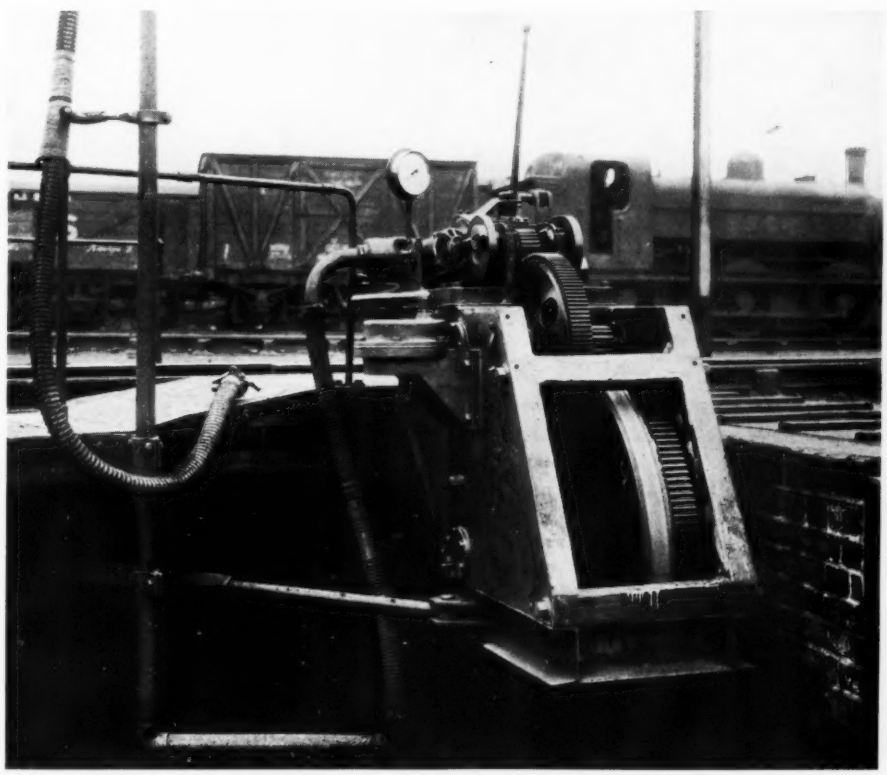
Cross sectional elevation through turntable and tractor; part plan showing general arrangement; and details of two-cylinder engine for vacuum-operated turntable at King's Cross locomotive sheds, L.N.E.R.

Tractor designed and supplied by Cowans Sheldon & Co. Ltd., Carlisle

turning effort is transmitted to the circular trackrail. The whole unit forms a tractor, the power for which is supplied by the locomotive being turned, through the medium of a pipe which couples on to the vacuum brake pipe on the locomotive and so enables the vacuum ejector to produce the necessary vacuum for the oscillating engine driving the tractor. Should the locomotive concerned not be in steam, the necessary power may be derived from vacuum accumulator tanks arranged one on each side of the turntable girders and connected to the engine as shown.

Speed changes and reversal are effected through the one operating lever, which works in conjunction with the four valves controlling the alternative admission of air or vacuum to the cylinders. The engine can be disengaged from the driving wheel if desired and the table turned by hand, while it is also possible to fix an emergency handle to the second motion shaft of the tractor, and thus turn the table by hand. The Tecalemit system of lubrication is used on the engine, the trunnions, and crankshaft bearings, which are of the anti-friction type. During our inspection of the apparatus we noticed the ease and smoothness with which a Pacific type locomotive, weighing with tender just under 150 tons, was turned without preliminary manœuvring to balance, and with considerable saving of time in the operation. What appealed especially to us was the fact that no outside power was required, the turning engine being worked by the locomotive itself. The tractor could thus be applied readily to any turntable, in any location, independent of outside sources of power supply. The apparatus, with slight modification, is equally applicable to operation with the compressed air system of braking. Drawings showing the latest developments of the engine and tractor are reproduced opposite.

View showing arrangement of the oscillating cylinder vacuum engine and its controls



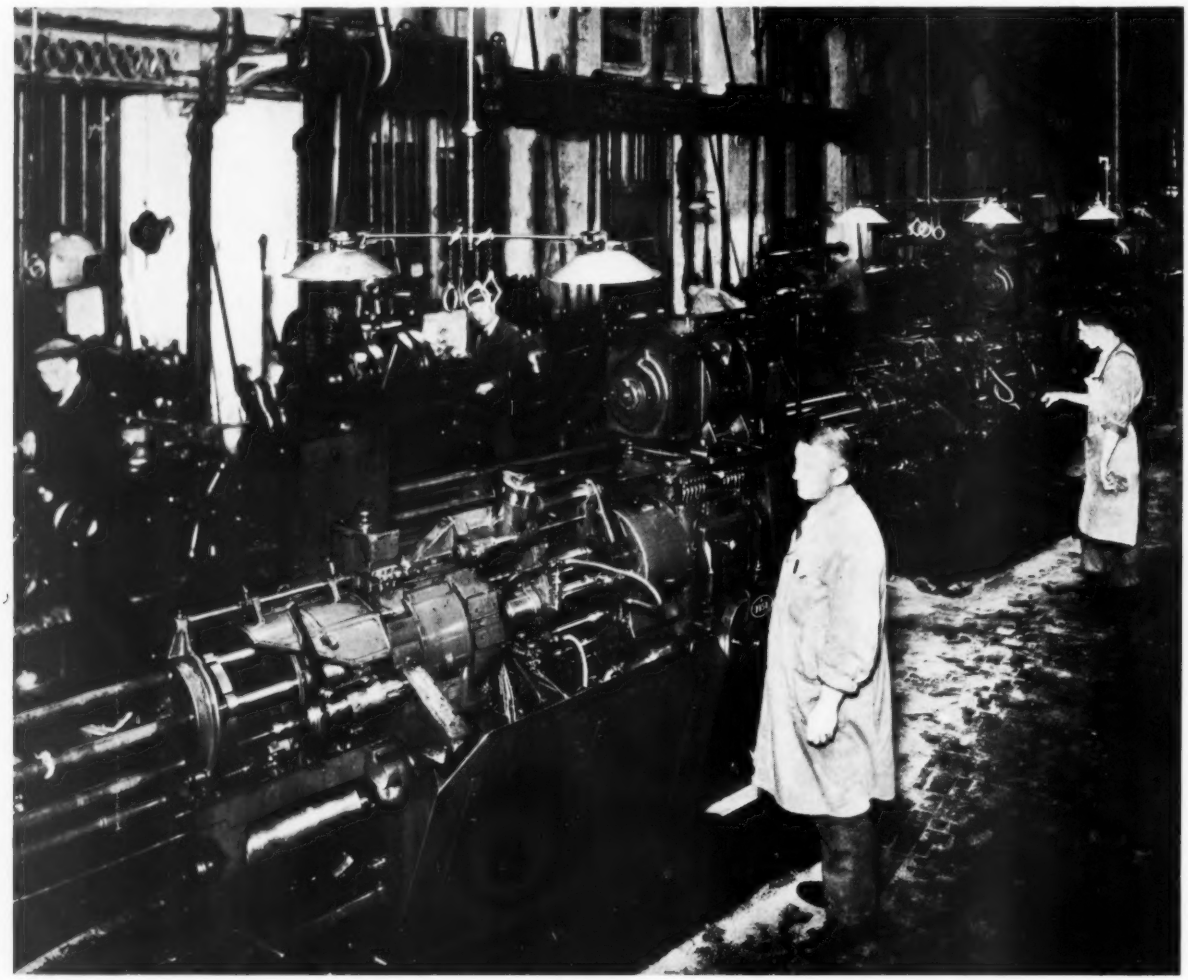
The transmission gearing and driving wheel of the vacuum-operated turntable at King's Cross locomotive sheds, L.N.E.R.

PRODUCTION OF STEEL FIREBOX STAYBOLTS

The use of Acme-Gridley five-spindle automatic screwing machines at Swindon works, G.W.R., has modified the process of producing staybolts for locomotive fireboxes

AFTER a considerable investigation of alternatives, three five-spindle Acme-Gridley automatic screwing machines of 1 in. capacity, designed and manufactured by B.S.A. Tools Limited, Birmingham, and supplied by Burton, Griffiths & Co. Ltd., have been installed at Swindon Works for the production of steel firebox staybolts. These machines have displaced a greater number of single spindle automatic machines with a consequent saving of floor space and other advantages. The machining procedure has been somewhat modified from that obtaining with the older machines, on which it was the practice to screw the complete length of stay as the first of four operations, then turn down the body of the stay, finish screwing with a second diehead, and part off.

On the five-spindle machines the waist is turned down in the first operation and this reduces by a minimum of about 48 per cent. the length of thread to be cut, the percentage reduction depending on the varying lengths of stays. Two rotary dieheads of the Coventry (Alfred Herbert Limited) type are employed. These are mounted on a crosshead actuated by the one lead screw and each can be adjusted horizontally to pick up the same thread; consequently both the roughing and finishing threads are cut simultaneously on two positions of the stock. Tungsten carbide turning tools are employed, and this has extended the time between re-grinds to approximately that of the dies, namely 2½ days. Extreme accuracy is demanded and maintained in thread diameters, form of thread and pitch. The maximum pitch error measured over a length of 5 in. is 0·0015 in. on the effective diameter under production conditions. The drive is obtained from a 10-h.p. motor mounted on the body of each machine. As the floor-to-floor times are approximately 30 per cent. of the previous times, the saving in floor space and operating costs is considerable.



Five-spindle automatic screwing machines in Swindon works, G.W.R., producing steel firebox stays

NEW METHOD OF FITTING CYLINDER AND STEAMCHEST LINERS

Scientific shrinking of locomotive cylinder and steamchest bushes by immersion in carbon dioxide

TEMPERATURE necessarily plays an important part in the fitting of locomotive cylinder and steamchest bushes, as shrinkage of the metal is relied upon for ensuring a secure and permanent assembly. The method now employed at the Swindon works of the Great Western Railway utilises the freezing qualities of solid carbon dioxide which is marketed by Imperial Chemical Industries, under the name of Drikold. A heat insulated vessel contains sufficient trichlorethylene to submerge the bushes to be dealt with, and this liquid is reduced to a temperature in the neighbourhood of 75° C. by Drikold, received in insulated containers in blocks weighing 25 lb. each.

Each bush is immersed in the cold liquid for about ten minutes, by which time it has been cooled to about 60° C. and reduced in diameter by three-quarters to one thousandth of an inch per inch of diameter. It is then lifted out of the liquid by irons, picked up with leather gloves and pushed into position in the cylinder.

The alternative method, which has been largely displaced, necessitates heating the cylinder by internal gas jets. This takes several additional hours, and further the application of heat to engine parts causes inconvenience in erecting operations. The freezing method is economical financially if twelve steamchest bushes or one main cylinder bush can be dealt with at a time. It follows, of course, that a lesser number of steamchest bushes can economically be dealt with if one cylinder bush is dealt with at the same freezing.

The accompanying illustration shows the freezing bath in the erecting shop at Swindon works with a 10-in. steamchest bush being lowered into the bath. The container can be moved from pit to pit by overhead crane or on a trolley.

Steamchest bush being lowered into freezing bath at Swindon works

NEW 4-6-4 TYPE INDUSTRIAL TANK ENGINE FOR SOUTH AFRICA

Built for hauling ore hopper wagons on heavy grades

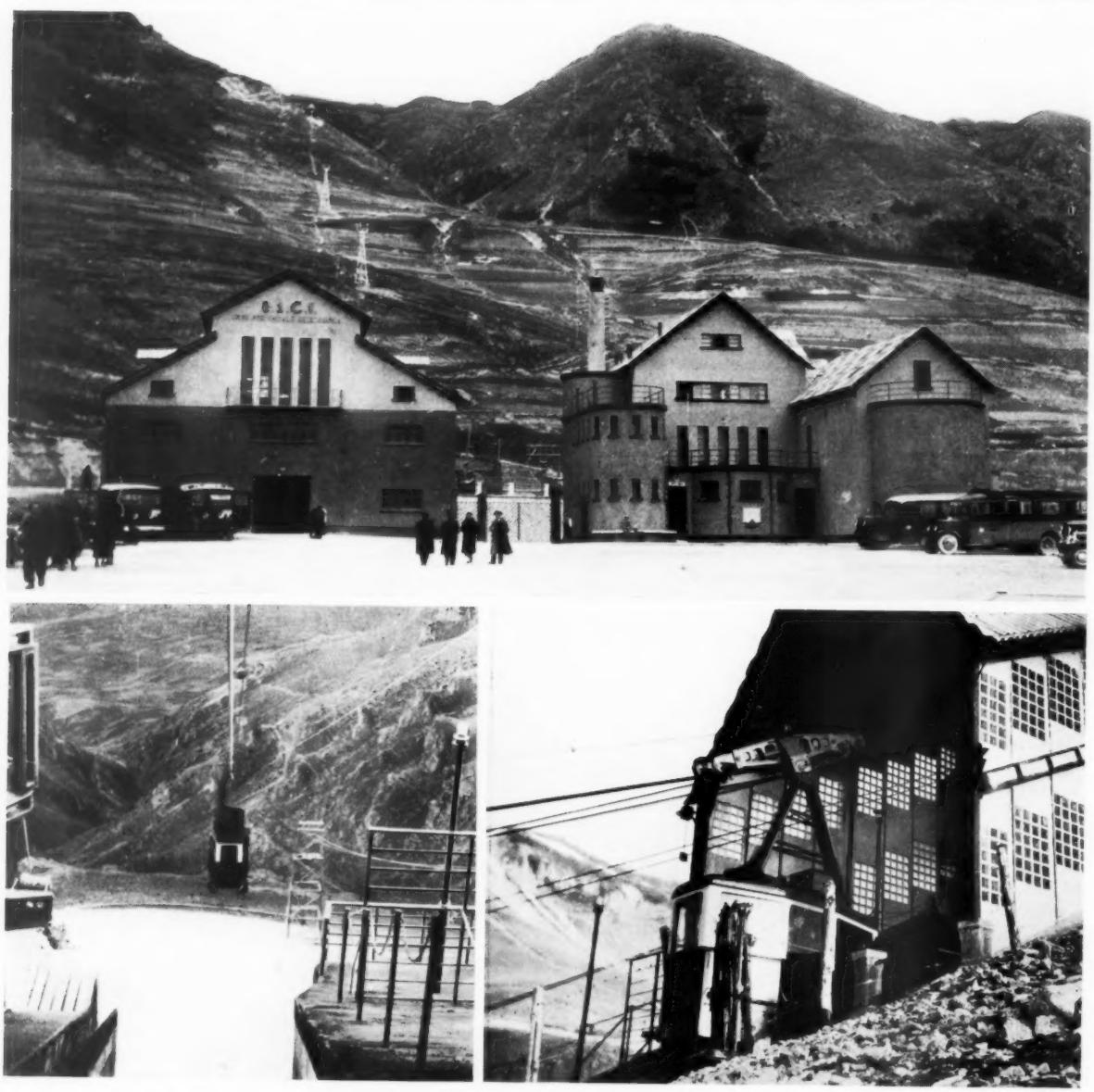
THE locomotive illustrated was recently completed at the works of R. & W. Hawthorn, Leslie & Co. Ltd., Newcastle-on-Tyne, and supplied through Sturrock (South Africa) Limited to the New Kleinfontein Co. Ltd., for hauling ore hopper wagons on heavy grades. Of the 4-6-4 type, it is designed to operate equally well when running in either direction and to suit the standard South African gauge of 3 ft. 6 in., being fitted with S.A.R.

New 4-6-4 industrial tank engine built by R. & W. Hawthorn Leslie & Co. Ltd. for the New Kleinfontein Co. Ltd.

control couplers and vacuum brake connections. The coupled wheels are 3 ft. 4 in. diam., and the leading and trailing bogie wheels 2 ft. 1½ in. diam., the bogies being duplicate. The rigid wheelbase is 9 ft. 6 in., and the total wheelbase 27 ft. The outside cylinders are 15¼ in. diam. by 22 in. stroke, with slide valves above, the valves being actuated by Allan straight link valve gear and rocker arms. The heating surface in the boiler tubes is 781 sq. ft. and in the firebox 82 sq. ft., giving a total of 863 sq. ft., with a grate area of 12·77 sq. ft. The working pressure is 180 lb. per sq. in.

Two No. 7 Gresham & Craven horizontal combination injectors placed on the barrel behind the dome feed the boiler, which is fitted with copper firebox and brass tubes. Asbestos mattresses are used for lagging. United States type metallic packing is fitted to the piston rods and valve spindles and the cylinders are lubricated by a Wakefield twin sight-feed Eureka lubricator fitted in the cab. Sunbeam electric lighting equipment is employed, large head lamps being provided at the front and the rear of the locomotive. Steam and hand brakes operate on all the coupled wheels, and vacuum brake equipment is provided for the train. The side tanks have a capacity of 1,220 gallons and the rear bunker a coal capacity of 3 tons.

In working order the total weight is 50 tons 18 cwt., of which 29 tons 13 cwt. is available for adhesion. Attention may be called to the somewhat unusual practice of using the 4-6-4 wheel arrangement in the class of traffic for which the engine has been built.



Views on the recently-opened funicular railway at Mount Gran Sasso d'Italia, built mainly to convey skiers to the top of the slopes of this famous central Italian winter sports resort. The skis will be noticed outside the car at the upper station, shown in the bottom right hand picture

RAILWAY NEWS SECTION

PERSONAL

At a meeting of the Irish Railway Clearing House Committee in Dublin on January 30, Sir Walter R. Nugent, Bart., was unanimously re-elected Chairman of the Committee for the year 1935.

Mr. Thomas K. Beck, Secretary to the General Manager, Central Argentine Railway, retired on pension on December 31, after 30 years' service with that company. Mr. Beck gained early experience in 1897 on the former Midland Railway of England, with which both his father and grandfather were connected. In 1904 he joined the old B.A. & Rosario Railway (now merged in the Central Argentine system) under contract, and for the first four years occupied various outdoor posts in the Traffic Department, including that of stationmaster. In 1908 Mr. Beck was transferred to the Management at Buenos Aires, and subsequently served in a confidential capacity under four General Managers. In May, 1928, he was appointed Secretary to the present General Manager, Mr. Ronald Leslie.

Mr. F. J. Leslie has been appointed to succeed Mr. Beck as Secretary to the General Manager. He entered the service of the Central Argentine Railway in 1913, and, after occupying posts in the Works Office and the Statistical Department, was transferred to the General Manager's office in 1920. He served in the Royal Navy during the War.

Mr. W. A. Pickwood, General Manager of the Antofagasta & Bolivia Railway, has returned to La Paz, after a tour in Europe and the United States.

Brig.-General A. S. Cooper, C.B., C.M.G., a Director of the Peruvian Corporation, arrived in Buenos Aires towards the end of December *en route* for Bolivia and Peru, there to make a tour of inspection of the various railways controlled by his company.

We regret to note the death, on February 3, of the Rt. Hon. John Henry Whitley, D.C.L., LL.D., J.P., late Speaker of the House of Commons and Chairman of the Royal Commission on Labour in India, 1929-31, and Chairman of the British Broadcasting Corporation since 1930.

Sir Percy Rothera, Kt., O.B.E., M.Inst.C.E., M.I.E. (India), who, as announced in THE RAILWAY GAZETTE of December 14 last, is retiring from the position of Agent of the South Indian Railway early this year, was educated at Rugby and began his engineering training with some four years' experience on the construction of the northern section of the Great Central Railway extension to London, under the late Mr. Edward Parry, M.Inst.C.E. In 1898, at the age of 21, he joined the South Indian Railway as an Assistant Engineer and rose through the various grades to be Chief Engineer. Mr. Rothera's work received the special recognition of the Home Board for its efficiency in carrying out the renewal of several large multiple span girder bridges by a method designed by himself and described in his paper "Renewal of Large Span Girders in Southern India" presented to the Institution of Civil Engineers in 1914, for which he was awarded the Indian Premium and a Telford Premium. During the war he saw service in Mesopotamia and rose to be Director of the Mesopotamian Railways, with the temporary rank of Lieutenant-Colonel. In recognition of his outstanding services he was awarded the O.B.E. After his return to the South Indian Railway, Mr. Rothera was appointed Agent in 1925 and seven years later received the honour of Knighthood. He was President of the Indian Railway Conference Association in 1930 and, having been the chief executive of his railway for nine years, Sir Percy is now the doyen of Indian railway agents.

Sir Percy Rothera, O.B.E., M.Inst.C.E.,
Agent of the South Indian Railway, 1925–35

INDIAN RAILWAY STAFF CHANGES

Mr. A. C. Griffin, O.B.E., has been appointed to officiate as Divisional Superintendent, Rawalpindi, N.W.R., as from November 13, 1934.

Mr. S. H. P. Lincke, Officiating Controller of Stores, Great Indian Peninsula Railway, reverted to his substantive appointment as Deputy Controller of Stores on that railway as from November 13, 1934.

Dr. R. J. Dyson, Chief Medical Officer, M. & S.M.R., returned from leave and resumed charge of his duties on January 3.

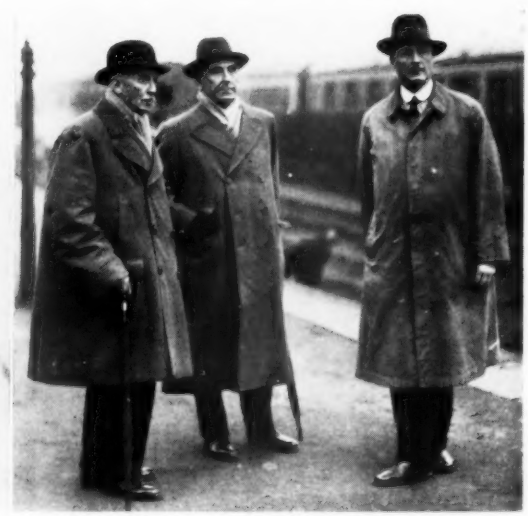
Major G. H. Kitson, a Director of the Monk Bridge Iron & Steel Co. Ltd., Leeds, has been elected President of the Leeds Chamber of Commerce.

Mr. R. Gardiner, who, as announced in THE RAILWAY GAZETTE of February 1, has been appointed Superintendent of the Southern Scottish Area of the L.N.E.R., entered the service of the old North British Railway in 1897. He was employed as a booking clerk at various places until 1901, was then transferred to the Commercial Department, and two years later entered the office of the Superintendent of the Line. After experience in the different sections of that office, he was appointed, in 1918, Assistant to the Assistant Superintendent of the Line. Between 1912 and 1915 Mr. Gardiner was engaged in connection with special traffic operating questions, including the layout and ramifications of the extensive system of N.B.R. train controls. In October, 1923, he was appointed Assistant District Superintendent, Sunderland (North Eastern Area), L.N.E.R., and in May, 1927, was transferred to the Newcastle District in a similar capacity. In November, 1927, he

Sir Robert Horne and Mr. C. S. Page (Chief Docks Manager), G.W.R.

Left to right: The Earl of Mount Edgcumbe, Sir Robert Horne, Lord Palmer, Lord Mildmay of Flete, and Mr. Charles J. Hambro on board one of the G.W.R. tenders at Millbay

Left to right: Mr. Charles J. Hambro, Sir James Milne, and Mr. A. Maynard (Chief Goods Manager), at the G.W.R. Docks, Millbay



Lord Mildmay of Flete, Sir Robert Horne, and Mr. J. H. Parker (District Traffic Manager) at North Road station, Plymouth

At luncheon at the Royal Hotel, Plymouth (left to right): Mr. Charles J. Hambro (Deputy Chairman), Vice-Admiral Sir Eric Fullerton (Commander-in-Chief), Lord Palmer (Deputy Chairman), the Mayor of Plymouth (Ald. J. E. Pillar), Sir Robert Horne (Chairman), Mr. R. J. Mitchell (Chairman, Plymouth Chamber of Commerce), Lord Mildmay (Director), and Vice-Admiral H. O. Reinold (Admiral-Superintendent, H.M. Dockyard)

Photos. by] **G.W.R. DIRECTORS AND OFFICERS AT PLYMOUTH** *[Western Morning News*

(See report in last week's issue)

was appointed Assistant Superintendent, Eastern Section, Southern Area, the position he now vacates to return to Scotland. Mr. Gardiner has closely identified himself with staff welfare, and has maintained personal contact with all operating grades. He has also taken a considerable interest in the Brotherhood movement and has frequently addressed meetings organised by the railwaymen at different centres. Having had a comprehensive musical training, Mr. Gardiner is naturally interested in the L.N.E.R. Musical Society, of which he is one of the Vice-Presidents. He has taken a keen interest in the Great Eastern Amateur Athletic Association, and is a member of the L.N.E.R. Golfing Society. He has been a frequent contributor to the proceedings of the various lecture and debating societies in the Southern and North Eastern Areas of the system.

Mr. R. Gardiner,

Appointed Superintendent, Southern Scottish Area, L.N.E.R.

Mr. R. W. Dawe, who, as announced in THE RAILWAY GAZETTE of February 1, has been appointed Chief Analytical Chemist and Chief of the Research Department, Swindon Laboratory, G.W.R., joined that railway as Assistant Analyst in 1915. From 1918-21, however, he was Senior Assistant to the Chief Chemist of the Great Southern and Western Railway of Ireland, but returned to the Great Western as Assistant Analyst at Swindon in the latter year. In 1927 Mr. Dawe was promoted to be Assistant to the Chief Chemist and Chief of the Research Department, the position he now vacates in order to take charge of the Chief Chemist's and Research Department from Mr. T. C. Davison, as from February 8.

Mr. R. W. Dawe,

Appointed Chief Analytical Chemist and Chief of the Research Department, Swindon Laboratory, G.W.R.

Mr. A. H. Lawson, who, as announced in THE RAILWAY GAZETTE of February 1, has been appointed Assistant Manager, Locomotive Factory, Swindon, G.W.R., joined the Locomotive Works Manager's office in 1897 and during the five years, 1898-1903, served his apprenticeship in the fitting, turning and erecting shops at Swindon. In the latter year he entered the testing house for experience, and was transferred to the drawing office in the following year. There he had experience in locomotive and boiler designing, hydraulics and survey, and, since March, 1931, has been in charge of the survey and water section, the position he now vacates to take over the duties of Assistant Manager in the locomotive shops.

Mr. A. H. Lawson,

Appointed Assistant Manager, Locomotive Factory, Swindon, G.W.R.

CROWN AGENTS APPOINTMENTS

Mr. W. Eraut, C.B.E., M.Inst.C.E., Chief Engineer (Contracts), retires from that position on March 21, and is succeeded by Mr. W. L. Watson, Assoc. M. Inst. C.E., Deputy Chief

Photo.] ***Group at the eighth annual dinner of the Royal Engineers Transportation Units*** *[Swaine*

(*See article on page* 250.)

Engineer. Consequent upon this appointment, Mr. A. Campbell, A.M.I.Mech.E., an Assistant Engineer, has been promoted to the rank of a Deputy Chief Engineer.

L.M.S.R. Appointments

The following appointments have been approved by the directors:—

Chief Commercial & Chief Operating Managers' Departments

Mr. F. W. Pearson, Chief Parcels Clerk, Leeds, to be Stationmaster, Leeds (Wellington).

Mr. D. T. Evans, Stationmaster, Manchester (London Road), to be Joint Stationmaster, Manchester (London Road—L.M.S.R. & L.N.E.R.).

Mr. W. L. Knight, Goods Agent, Halifax, to be Joint Goods Agent, Halifax (L.M.S.R. & L.N.E.R.).

Mr. D. Fazackerley, Goods Agent, Trafford Park and Manchester Docks, to be Joint Goods Agent, Widnes (L.M.S.R. & L.N.E.R.).

Chief Commercial Manager's Department

Mr. T. W. Royle, Assistant Chief Commercial Manager, Euston, to be Chief Assistant Commercial Manager, Euston.

Mr. C. N. Mansfield, Assistant Mineral Manager, Derby, to be Assistant Chief Commercial Manager (Coal), Euston.

Mr. J. P. Crompton, Chief Clerk, Mineral Department, Derby, to be Assistant, Chief Commercial Manager's Department (Coal), Derby.

Mr. G. Dowding, Assistant to District Passenger Manager, Manchester, to be Chief Parcels Clerk, Chief Commercial Manager's Office, Euston.

Mr. W. S. Carson, Assistant Superintendent, Wyre Docks, Fleetwood, to be Chief Commercial Clerk, District Goods Manager's Office, Manchester.

Chief Operating Manager's Department

Mr. S. E. Parkhouse, Assistant (Freight Services), Euston, to be Divisional Superintendent of Operation, Crewe.

Mr. C. Phizackerley, Assistant Divisional Superintendent of Operation, Crewe, to be Assistant (Freight Services), Euston.

Mr. L. P. Ball, Divisional Controller (Freight Services), Crewe, to be Assistant Divisional Superintendent of Operation, Crewe.

Mr. A. P. Hunter, Divisional Controller (Passenger Services), Crewe, to be Divisional Controller (Freight Services), Crewe.

Mr. E. Taylor, Assistant Divisional Controller (Freight Services), Manchester, to be District Controller, Huddersfield.

Mr. W. Dawson, Chief Controller, Manchester, to be Assistant Divisional Controller (Freight Services), Manchester.

Mr. I. E. Mercer, District Locomotive Superintendent, Bolton, to be District Locomotive Superintendent, Wellingborough.

Astonishing Locomotive Performance in France

A description of running over the various French main lines with locomotives of the rebuilt Paris-Orleans type, or which have been modified on the lines of these well-known P.-O. conversions. Some very striking feats of load haulage, uphill running, and sustained high speed are included

(*See editorial article on page* 224)

Some details of exceptional interest concerning modern French locomotive performance have reached us recently from Baron G. Vuillet, and collectively form a remarkable tribute to the effect on tractive capacity of the improved methods of steam generation and flow first introduced on the Paris-Orleans Railway, and now generally adopted by French railways. It is doubtful if ever previously in the history of the steam locomotive such feats of haulage, proportionately to the weight and nominal tractive effort of the engines concerned, have been set on record.

Rebuilt Pacific No. 231.722, P.O.-Midi Railway showing the new numbering

The weights of train figuring in the notes that follow are gross weights. In calculating the gross weight of a train in France, passengers are assessed at 75 kg., inclusive of hand luggage (which works out at 165 lb. a head), and are regarded as having in addition 30 kg. of luggage in the van. Allowance is also made for the weight of mails, parcels, &c., carried on the train. In the winter months, when steam heating is in use, a further allowance is credited to the engine-crew, on a percentage basis, for the use of steam, to compensate them for the additional coal consumption entailed, which otherwise might cause a deduction from their coal-saving bonus; but the steam heat allowance is not included in the runs about to be described.

Modern French stock is, by comparison with British, weighty. For example, train No. 1004 on the P.L.M., leaving Vichy at 11.8 a.m. for Paris, is made up of restaurant car (54 *tonnes*), Pullman car (56 *tonnes*), six first and second-class composites averaging 45·5 *tonnes* apiece, and a 6-wheeled van of 21 *tonnes'* weight, the nine cars thus weighing 404 *tonnes* empty and 431 *tonnes* with the allowances mentioned in the last paragraph. Corresponding weights in British equivalents are 398 tons and 425 tons respectively. Heavier coaches than these are in use, however. The latest all-steel first and second-class composites of the P.O.-Midi Railway weigh 50·5 *tonnes*, Est first-class coaches 49 *tonnes*, P.L.M. steel-panelled stock 48 and 49 *tonnes*, and so on. The Calais-Mediterranée express of the P.L.M. (the Blue Train) consists of ten cars weighing 575 *tonnes*, or 566 tons. On the other hand, at high speeds, when, of the resistances affecting motion, air resistance comes into greater prominence, the effort demanded of the locomotive has not risen proportionately to tare, and on level track at least the number of cars in the train is probably a more important figure than their weight.

Paris-Orleans-Midi

In giving examples of present-day work in France, it is fitting that a beginning should be made with the Paris-Bordeaux main line of the P.O.-Midi system, as the P.O. Company has been more responsible than any other for the improvements in design which have made possible the performances

recorded in this article. Probably the hardest of its trains, especially in summer, is No. 3, leaving Paris (Quai d'Orsay) at 8.40 a.m., and making numerous stops on very smart point-to-point timings. In this case rebuilt Pacific No. 3717 was at the head of a 17-coach train with a gross weight of 798 *tonnes* (784 tons), which it took over at St. Pierre-des-Corps from the electric locomotive which had worked No. 3 from Paris to that point. Up the 4¾ miles at 1 in 200 from the start speed rose to 39 m.p.h., and after attaining 66 m.p.h. down 1½ miles at 1 in 200 before Monts, the engine mounted the 7 miles averaging 1 in 225 past Villeperdue at an average speed of 56 m.p.h. and a minimum of 52·5 m.p.h. The 42·5 miles from St. Pierre-des-Corps to Chatellerault were run in 46 min., start-to-stop, and the 20·5 miles thence to Poitiers in 23 min., with a maintained speed of 67 m.p.h. on the level. From Poitiers to St. Saviol the 32·0 miles were run in 36 min., with a maintained speed of 48·5 m.p.h. up the 5 miles at 1 in 200 past Couhé-Verac. The short stretch of 8·7 miles from St. Saviol to Ruffec was run in 12 min., start-to-stop, with a maximum speed of 65 m.p.h., and a fast run was made over the 29·5 miles from Ruffec to Angoulême in 31 min., with a top speed of 78 m.p.h., and a minimum of 55 m.p.h. up the 4 miles at 1 in 200-250 before St. Amand.

When the regulator was opened to start the train from Angoulême, the effort of the engine was such as to break a drawbar, putting one of the large vans out of action. This necessitated the transfer of its contents to two other vans, bringing the load up to 19 vehicles, of 819 tonnes (807 tons) weight. The driver's laconic comment to his fireman, on getting away 28 min. late from Angoulême—and the only words exchanged between the two men for the next hour—was, "We shall have to work." Up the ascent to the tunnel at Charmant, 12 miles in length, and varying chiefly from 1 in 250 to 1 in 192, speed was maintained steadily at 53 to 54 m.p.h.; the summit, 15·5 miles from Poitiers, was passed in a shade under 21 min. The engine here was being worked at 60 per cent. cut-off in the h.p. cylinders, and 58 per cent. in the l.p.; and the temperature of the steam in the h.p. steam-chests rose to 790° F. From Montmoreau to Coutras speed ranged between 71 and 78 m.p.h., and the 50·6 miles from Angoulême to Coutras, scheduled to be covered in 57 min., were actually covered in 50 min. start-to-stop. During this part of the run the engine was fired with briquettes at approximately 40-sec. intervals, and on the ascent to Charmant tunnel was developing 2,200 h.p. at the drawbar continuously. The 9·9 miles from Coutras to Libourne were covered in 13 min., start-to-stop, and between these points a speed of 71 m.p.h. was attained on the level. Unfortunately, between Libourne and Bordeaux (Benange), a permanent way check was in operation, causing a delay of 3 min., but both before and after this a speed of 71 m.p.h. was attained, the 21·8 miles taking 26 min., start-to-stop. The average cut-off on the journey was 50 per cent. in both sets of cylinders, without any shortage of steam in the course of five hours' working of this enormous train. Only once did the engine slip, and that was in starting from Ruffec. In all, 22 min. had been gained on schedule from Angoulême to Bordeaux—mostly in recovery of overtime at stations—and of this 15 min. had been recovered between Angoulême and Bordeaux alone, with the 807-ton load. The observer on the footplate noted that when the engine was working at its hardest, despite the speed, the two jets from the Kylchap blast-pipe rose fully 50 ft. into the air. This load of 808 tons was not a record, as train No. 34 (a night service) from Bordeaux to Paris has been made up to 905 tons without pilot assistance.

P.O. 4-8-0 Performances

On the Toulouse line the introduction of the twelve 4-8-0 locomotives rebuilt, with the same improvements, from earlier Pacifics, has enabled remarkable work to be performed with the Barcelona Express which often exceeds 600 tons. This is, moreover, a route of exceptional difficulty. There are lengthy 1 in 100 grades—in one case all but 25 miles long, chiefly at this inclination, and with 25-chain radius curves, which by their resistance are calculated to reduce the 1 in 100, in effect, to 1 in 87; over the 148·3 miles from Limoges to Caussade, again, speed is limited to a maximum of 53 m.p.h. In these circumstances, to maintain an average speed of 44·2 m.p.h. over the 248·2 miles from Chateauroux to Montauban, inclusive of stops, requires with a train of over 600 tons weight, locomotive work of the highest order.

On the south-bound Barcelona Express, Baron Vuillet sends details of a footplate run on engine No. 4702, with a 14-coach train of 617 *tonnes* gross (608 tons). Issoudun, 22·3 miles from Vierzon, was passed in 23 min. 32 sec., and Chateauroux, 39·1 miles, was reached in 45 min. 35 sec., or 41 min. net, a permanent way check having been experienced beyond Issoudun. The maximum speed reached was 70 m.p.h. From Chateauroux, with the engine cutting off at 18 per cent. in the h.p. cylinders and 23 per cent. in the l.p., the train passed Argenton, 19·3 miles, in 20 min. exactly, maintaining 68 to 71 m.p.h. for 8¾ miles. Cut-off was then advanced to 40 per cent. in the h.p. cylinders and 45 in the l.p. for the climb of 21·8 miles to Forgevieille, which begins at 1 in 100, and then flattens to 1 in 167; this was covered in 30 min. 42 sec., at an average of 42·8 m.p.h., and with a minimum of 36 m.p.h. on the 1 in 100. On the undulating lengths beyond the summit speed was not allowed to exceed 69 m.p.h., and there was a minimum of 49 m.p.h. up the short 1 in 166 beyond St. Sulpice; to this point, 64·2 miles from Chateauroux, the time was 74 min. 15 sec.; and Limoges, 85·3 miles, was reached in 96 min. precisely. On the Limoges-Brive section interest centred chiefly in the ascent from Pierre-Buffière to La Porcherie; this 13·5-mile length, which is chiefly at 1 in 100, apart from about 2 miles level and downhill past St. Germain, was covered in 20 min. 20 sec., at an average of 40·0 m.p.h. Speed had fallen to 31 m.p.h. when cut-off was increased to 50 per cent. in all cylinders; this resulted in an acceleration to 36 m.p.h. on the 1 in 100, and to 53 on the easier section past St. Germain, while the summit was breasted at 39 m.p.h. Despite the limitation of maximum speed to 53 m.p.h., and a permanent way check costing 2½ min., the 61·3 miles from Limoges to Brive were run in 83 min. 33 sec.

In the reverse direction No. 4702 of the same type, with a 13-coach train weighing 602 *tonnes* (594 tons), cutting off at 41 per cent. in the h.p. cylinders and 45 per cent. in the l.p., made the ascent of 24·9 miles from Allassac to La Porcherie, mainly at 1 in 100, but with occasional short flattenings to 1 in 167, in 36 min. 28 sec., at an average of 40·8 m.p.h.; speed was 43 m.p.h. at Allassac, 37 m.p.h. on the 1 in 100 beyond, 50 m.p.h. at Vigeois, 35 m.p.h. above Uzerche, 43 m.p.h. at Salon la Tour, and 40 m.p.h. at the summit. Allassac, 10·2 miles, was passed in 17 min. 30 sec., La Porcherie, 35·1 miles, in 53 min. 58 sec., and with no speed exceeding 53 m.p.h. Limoges was reached in 88 min. After Limoges there is a heavy climb, varying from 1 in 91 to 1 in 167, up to La Jonchère; the 10·7 miles from Le Palais (after attaining speed) to the summit were covered in 16 min. 8 sec., at 40·0 m.p.h. average, with a minimum of 31 m.p.h. on the 1 in 100, and after a signal check costing 2½ min. at St. Sulpice (passed in 32 min. 50 sec., 21·1 miles), Forgevieille, 44·2 miles, was passed in 58 min. 3 sec., and the remaining 41·1 miles to Chateauroux were covered in 38 min. 47 sec., with speed limited to 65 m.p.h. down the 1 in 100 grades, but elsewhere rising to 74 m.p.h. On the final stage to Vierzon, a maximum of 76 m.p.h. was reached on a 1 in 666 downgrade, with 22 per cent. cut-off in the h.p. cylinders and 28 per cent. in the l.p., while 65 m.p.h. was maintained up 1 in 333, with respective cut-offs of 27 and 33 per cent. A permanent way check was experienced before Issoudun (16·8 miles in 20 min. 34 sec., or 17 min. net), but after that 74 m.p.h. was maintained continuously, and Vierzon, 39·1 miles, was reached in 40 min. 40 sec., or 37¼ min. net from Chateauroux, start-to-stop. The 4-8-0 locomotives now work this train throughout between Vierzon and Narbonne, with a change of locomotive at Brive.

(To be continued)

Royal Engineers Transportation Units

(See illustration on page 247)

Colonel Sir Herbert Walker, K.C.B., General Manager, Southern Railway and Honorary Colonel, Transportation Units, Supplementary Reserve, presided at the 8th annual dinner of the Royal Engineers Transportation Units, which was held on Friday, February 1, at the Abercorn Rooms, London. Those present included:—

Capt. J. H. Anderson, R.E.; Capt. R. E. Bagnall-Wild, R.E.; Major F. J. Biddulph, M.C., R.E.; Lt. H. T. Bird, R.E. (S.R.); Col. W. E. Blakey, M.M.; Capt. J. Blundell, R.E. (S.R.); Lt.-Col. F. T. Bowler; Lt. N. E. V. Brady, R.E. (S.R.); Lt. K. Brimsmead, R.E. (S.R.); Capt. C. E. A. Browning, R.E.; Capt. P. D. G. Buchanan, R.E.; 2nd Lt. T. D. Burdis, R.E. (S.R.); Lt. W. H. Cantrell, R.E. (S.R.); Major A. B. Chester, R.E. (S.R.); 2nd Lt. A. J. Clarkson, R.E. (S.R.); Capt. E. C. Cookson, R.E. (S.R.); Major E. T. Davies, M.C. (R. of O.); Lt. Col. J. V. Denning, M.C, R.E. (S.R.); Lt. W. A. Dobson (R. of O.); Lt. C. M. Field, R.E. (S.R.); Lt. S. A. Finnis, R.E. (S.R.); Major R. F. O'D. Gage, M.C., R.E.; Mr. P. Gibb; Lt. R. S. Grant, R.E.; Lt. F. M. Grazebrook, R.E.; Capt. J. A. B. Grylls, R.E.; Mr. F. E. Harrison, O.B.E.; Capt. C. E. M. Herbert, R.E.; Major F. Holland, R.E. (S.R.); Lt. V. R. Illingworth, R.E. (S.R.); Capt. N. E. B. Jeffrey, R.E. (S.R.); Lt. R. M. Jones, R.E.; Mr. J. A. Kay; Capt. L. J. M. Knotts, R.E. (S.R.); Major C. A. Langley, M.C., R.E.; Lt. J. A. Lemon, R.E. (S.R.); Lt. C. R. A. Linton, R.E. (S.R.); Lt.-Col. L. Manton, D.S.O., O.B.E., R.E.; Capt. L. E. Marr, R.E. (S.R.); Lt. D. C. Merry, R.E.; Mr. J. Miller; Lt. H. G. Neale, R.E. (S.R.); Capt. G. A. Palmer, R.E.; Capt. C. P. Parker, M.C., R.E. (S.R.); Capt. E. L. Parkes, R.E.; Lt. A. C. J. Payne, M.M., R.E. (S.R.); Major A. S. Quartermaine, M.C. (R. of O.); 2nd Lt. H. Randle, R.E. (S.R.); Lt. J. Ratter, R.E. (S.R.); Capt. R. J. Reed, R.E. (S.R.); Lt. General Sir Felix F. Ready, K.C.B., C.S.I., C.M.G., D.S.O.; Lt. C. R. L. Rice, R.E. (S.R.); Major V. A. M. Robertson, M.C.; Mr. L. G. D. Rock; Mr. S. G. Rowe; Major J. R. Sadler, R.E. (S.R.); Major H. F. Sanderson, R.E. (S.R.); Lt. L. Sanson, R.E. (S.R.); Major J. Scott, M.C., R.E. (S.R.); Lt. W. J. Scott, R.E. (S.R.); Lt. Col. H. A. Short, M.C., R.E. (S.R.); Lt. F. C. C. Stanley, R.E. (S.R.); 2nd Lt. S. Stevens, R.E. (S.R.); 2nd Lt. B. M. Strouts, R.E. (S.R.); Lt.-Col. G. S. Szlumper, C.B.E., T.D.; Major R. Tandy, R.C. of Sigs.; Lt. S. M. Taylor, R.E. (S.R.); Lt. M. B. Thomas, R.E. (S.R.); Col. W. G. Tyrrell, D.S.O.; Major S. E. Tyrwhitt, R.E. (S.R.); Maj.-Gen. W. R. Venning, C.M.G., C.B.E., M.C.; Col. Sir Herbert A. Walker, K.C.B., T.D.; Lt. W. H. T. Wheeler, R.E.; Sir Murrough J. Wilson, K.B.E.; Major G. R. S. Wilson; Capt. K. L. Yorath, R.E. (S.R.).

Colonel Sir Herbert Walker said the order of the evening was that there were to be no speeches, but he felt he could not let the occasion pass without referring to the fact that Colonel Manton, who had been Commandant of the Royal Engineers' Railway Training Centre at Longmoor for the past five years, was shortly vacating his appointment on completion of tenure. In any war transportation must play a very important part, and he paid a warm tribute to the excellence of the instruction that had been given under Colonel Manton at Longmoor.

Lt.-Colonel Manton, in responding, thanked all the members of the Railway Units of the Supplementary Reserve for their hard work and co-operation. They would be ten years old this year, and he had been commandant for nearly half that period. Continuing, he emphasised the importance of being certain of one's line of communications in war. To ensure this efficient transportation was essential. The annual training which the railway companies underwent at Longmoor enabled their technical knowledge of railway construction and operation to be adjusted to military requirements. By their annual training they kept themselves efficient and available immediately to fulfill a function that would otherwise have to be carried out by a branch of the regular army. He appreciated the support received from the railway general managers and other officers and their visits to Longmoor. His experience there was a happy memory that nobody could take away and he parted from them all with his best wishes for their future.

Lt. General Sir Felix F. Ready related some amusing reminiscences of his military experiences during the past 43 years. He was followed by Colonel W. E. Blakey, M.M., who expressed the regret of all the officers of the Railway Units that Colonel Manton was leaving Longmoor. All came away from their period of training with a great deal more knowledge than when they went. Lt. Colonel F. T. Bowler proposed the toast of "The Chairman" and Sir Herbert Walker in responding expressed his pleasure at being present.

The Creation of New Demands for Transport

Mr. F. R. E. Davis, Secretary of the Great Western Railway Company, presided at the meeting of the G.W.R. Debating Society at Paddington station on January 24, and presented book and medal prizes to the winners in the Society's annual prize essay competition. Following the presentation of awards, the first prize winner, Mr. B. S. Potter, Chief Goods Manager's office, read his essay on "New demands for transport; how they may be created and developed profitably by the Great Western Railway Company."

The essay contained a number of interesting suggestions in connection with the difficult question of creating and developing fresh transport demands. The essayist said it had been estimated authoritatively that the public spent £46,000,000 more in travel in 1932 than in the average for the years 1924-27, a figure which proved the rapidly-growing desire of people to move about the country, chiefly for pleasure. A good way of appealing to the imagination of the public would be to try to make people look upon the railway in the same light as they would upon something new. Emphasis should be laid on the fact that rail travel helps to keep people physically and mentally fit by conveying them from place to place in a safer, more comfortable, speedy and nerve-saving manner than any other transport system. Stations should be brightened up and made attractive, so that they may become hubs of life no less than are market places and public houses. A great extension should be made in the provision of facilities at stations for car and cycle parking and garaging; parking should be free in certain circumstances. Further encouragement should be given to travel on Sundays and in the evenings by means of extended excursion bookings. The number of canvassers should be increased, and an effort be made to secure the best available men for this important work. The potentialities of the light diesel-engined unit should be further explored.

On the goods side there was need for constant exploration of further means of service, designed to save traders trouble and inconvenience as well as cost. In this respect the "agreed charge" was especially valuable, while the potential demand for warehousing was probably far from satisfied. Overnight transits having been perfected for main flows of traffic over distances up to 300 miles, the next objective should be to offer same day delivery for certain traffics, such as live-stock and household removals. In connection with housing schemes, the establishment of railhead distribution centres for bricks, timber, and other materials might be a useful development. The present favourable money conditions offered an opportunity for the railway company to consider the flotation of a subsidiary company for land investment and industrial development.

The Chairman initiated an interesting discussion, which was entered into briskly by competitors in the essay competition.

THE INSTITUTE OF METALS.—The annual general meeting of the Institute of Metals will be held in London on March 6 and 7 next. The annual dinner and dance is to take place at the Trocadero on March 6 and for the afternoon of March 7 a visit has been arranged to the Battersea power station. The institute has now completed its plans for an educational tour to Germany for junior members, college students and members of staffs of educational and research institutions. This is due to leave London on April 6 and to return on April 15. Several important works of metallurgical interest in the Rhineland will be inspected.

PARLIAMENTARY NOTES

Electricity Supply Bill

The House of Lords on January 31 gave a second reading to the Electricity Supply Bill. In addition to some amendments regarding general supply of the Act of 1926, the Bill provides by clause 4 that the Central Electricity Board may give supplies direct to any railway company, subject to the board satisfying the Electricity Commissioners that the supply will not result in any financial loss to the board. It may be recalled that the Bill was passed last session by the House of Lords, but time did not allow of its disposal by the House of Commons. In the present session, the Government brought forward the Bill in the House of Commons, where in the latter part of last year it was passed through all its stages (as was reported in THE RAILWAY GAZETTE) and sent on again to the House of Lords. As the Bill had been dropped in last session it has to go through its various stages afresh.

The Earl of Munster (Lord in Waiting) now, on behalf of the Government, moved the second reading of the Bill. Having referred to other provisions, he said that clause 4, although it only gave effect to a recommendation of Lord Weir's Committee, appeared to be the most controversial in the Bill. The clause would enable the railways to negotiate direct with the board and would remove an obstacle to securing supplies for main line electrification. In the case of a large scheme of electrification it would be impracticable if not hopeless for a railway company to negotiate elaborate individual agreements with a number of separate undertakers through which the railway line ran.

Lord Mount Temple said that the Bill had been called a great advance in Socialism, but those who would suffer most were the municipalities. Under clause 4 there would be a diminution of municipal trading rather than an extension.

Lord Strabolgi said that the Bill was not the Labour party's idea of Socialism, but they supported it because they thought it was the best compromise they could expect.

Lord Wolverton expressed the hope that the railway companies might see their way to electrifying more of their lines in the near future. He hoped, however, that clause 4 would not be taken as a precedent with regard to any other industry.

Lord Monkswell contended that the Bill should be referred to a Select Committee. He regarded the question of main line electrification from a technical point of view with the utmost misgiving. He could not find any justification for statements about the magnificent success of the Southern Railway electrification. At meetings of that company shareholders had shouted "Give us the figures," but they had been refused. The administration of the Southern Railway dared not give the figures; they were engaged in throwing good money after bad in electrifying greater stretches of their railway. Their Lordships should go into the subject carefully before the administration committed themselves to the frightful losses which might be incurred.

The Earl of Munster, in reply, said he would refer to a speech by Sir Robert Horne in the House of Commons on the Bill, which gave hopes that the difficulties which had beset the railway companies in not knowing whether they would be able to bargain well with every undertaking on all sections of the line would be destroyed by the Bill, and that they would be able to deal with one company direct. In that case it must be obvious that the railway companies would now have a definite start for considering whether or not they should go in for electrification schemes. They could, of course, make further inquiries as to the cost involved, but he could not be expected on behalf of the Government to enter into a long argument as to whether electrification of the main lines was or was not desirable. It was not the intention of the Government to damage municipal undertakings in any way, and he did not think the Bill affected municipal undertakings. He could assure Lord Wolverton that the Bill would not be taken as a precedent. There was no intention on the part of the Government to give further help to other individual companies.

The second reading of the Bill was agreed to.

A motion by Lord Mount Temple to refer the Bill to a Select Committee was negatived, the Earl of Munster pointing out that such a course would delay the Bill for a considerable time.

L.N.E.R. Bill

The L.N.E.R. Bill, which was presented and read a first time in the House of Commons on January 30 last, was on Monday (February 4) read a second time in that House, and referred to the Examiners of Petitions for Private Bills. The Bill proposes to make permanent for the company's canals the temporary increases in charges—first sanctioned by the Ministry of Transport in 1920—of 60 per cent. above the previously authorised maxima. These temporary increases would otherwise expire on December 31 next. It is proposed to relieve the company of the obligation to maintain as a navigable waterway the canal extending from Grantham to the Trent. Further powers are asked as to the retention, sale and disposal of lands. Extensions of time are required for completion of certain authorised works, but no powers are being taken for new works or additional capital. Eight petitions have been deposited against the Bill, the petitioners including the Grantham and Nottingham Corporations, and owners of property abutting on the Grantham Canal.

G.W.R. Bill

A second reading was given in the House of Commons on Monday (February 4) to the G.W.R. Bill, which had been read a first time on January 30. It has been referred to the Examiners. The Bill proposes to make permanent the temporary increases in canal tolls and charges above the statutory maxima laid down in 1894, which increases were first sanctioned by the Ministry of Transport in 1920, and are due to expire on December 31 next. Power is also taken to abandon a portion of the Stourbridge Extension Canal. Extensions of time are asked for compulsory purchase of lands and for construction of certain authorised works, but no powers for new works or new capital are included in the Bill.

P.L.A. Bill

The House of Lords gave a second reading on February 5 to the Port of London Authority Bill which empowers the Authority to lower the L.N.E.R. North Woolwich branch where it passes under the passage between the Albert and Victoria Docks and to deepen the passage. An agreement scheduled to the Bill makes the Authority responsible to the L.N.E.R. for the whole cost of lowering and interfering with the branch. A widening and improvement of the main Victoria Dock is also proposed, and it is intended to dredge and deepen the Victoria and Albert Docks to a depth not exceeding 36 ft. Power is taken to levy dues on seaplanes using the waterway or docks of the Authority and to make charges on goods imported or exported by such seaplanes.

G.W.R. GLOUCESTER AMBULANCE CORPS DINNER.—Mr. S. Morris, Divisional Superintendent and President of the G.W.R. Gloucester Ambulance Corps, presided over the annual dinner of the corps held at the Spread Eagle Hotel, Gloucester, on February 2, supported by the Mayor (Mr. William H. Nicholls), the City High Sheriff (Mr. A. H. Palmer), the City Member (Mr. H. Leslie Boyce), and other local officials and officers of the G.W.R. Mr. Morris, reviewing the progress of the ambulance movement on the G.W.R., said that, since the inception of the company's long service award, no fewer than 2,717 gold medals for 15 years' ambulance efficiency had been issued to members of the staff. Mr. Boyce paid eloquent testimony to the efficiency of the Gloucester Ambulance Corps and its value in the city of Gloucester. Gold bars and medals gained by members for 15, 20, and 30 years' efficiency were distributed by the Mayor, who, in congratulating them, wished the corps and the G.W.R. every success in the future. A tribute of appreciation was paid to Dr. F. H. Stallman, the class lecturer.

NOTES AND NEWS

Northern Counties (L.M.S.) Traffics.—Railway traffic receipts of the Northern Counties Committee (L.M.S.) for the first 4 weeks of 1935 have amounted to £22,857, an increase of £1,244, or 5·44 per cent.

R.A.S. Record Flight.—The L.M.S.R. reports that a record flight from Belfast to Liverpool and Croydon was made on Saturday last by the Railway Air Services air liner *Mercury*. The actual flying speeds were 151 m.p.h. from Belfast to Liverpool, and 169 m.p.h. from Liverpool to Croydon.

L.N.E.R. Guaranteed Stock.—The London & North Eastern Railway Company has placed privately £60,417 four per cent. first guaranteed stock. The created amount of this stock is £33,066,831, and the present placing brings the stock issued up to the authorised total.

New Streamlined Train Service in America.—The three-car Union Pacific streamlined train was placed in regular service between Salina, Kansas, and Kansas City, Mo., on January 31, the 187 miles being covered in 3½ hours. A six-car and two nine-car streamlined trains are to be placed in service between Chicago and the Pacific coast in May.

Brussels Junction Railway.—The scheme for connecting the two main terminal stations in Brussels, the Nord and the Midi, by means of a direct line through the city, with a main central station about midway, is likely to be discussed in the Belgian Parliament before long. Work was begun before the war but was suspended and the works left derelict. These were illustrated on page 408 of our issue of September 25, 1931, in which issue also we outlined the various proposals then being revived.

Road Accidents.—The Ministry of Transport return for the week ended February 2 of persons killed or injured in road accidents is as follows :—

	Killed		Deaths resulting from previous accidents		Injured	
England	85	(87)	36	(26)	2,728	(2,955)
Wales ...	3	(4)	—	(2)	113	(111)
Scotland	11	(7)	5	(2)	299	(300)
	99	(98)	41	(30)	3,140	(3,366)

The total fatalities for the week were, therefore, 140, as compared with 128 for the previous week.

American Railplane.—The so-called Railplane, built by the Pullman-Standard Car & Manufacturing Company, and described and illustrated in THE RAILWAY GAZETTE for December 8, 1933, is now in regular passenger operation on the Gulf, Mobile & Northern Railroad, between Tylertown and Jackson, Mo., and is making a daily mileage of 320. This vehicle seats 50 passengers on a tare weight of 11¼ tons and has a top speed of 90 m.p.h.

Parcels Delivery in the North.—On February 1, the United Automobile Services Limited, an associate of the L.N.E.R., took over control of Trutime Deliveries Limited, a company with headquarters in Newcastle-on-Tyne, which conducts an extensive parcels delivery service throughout a large area in the north of England.

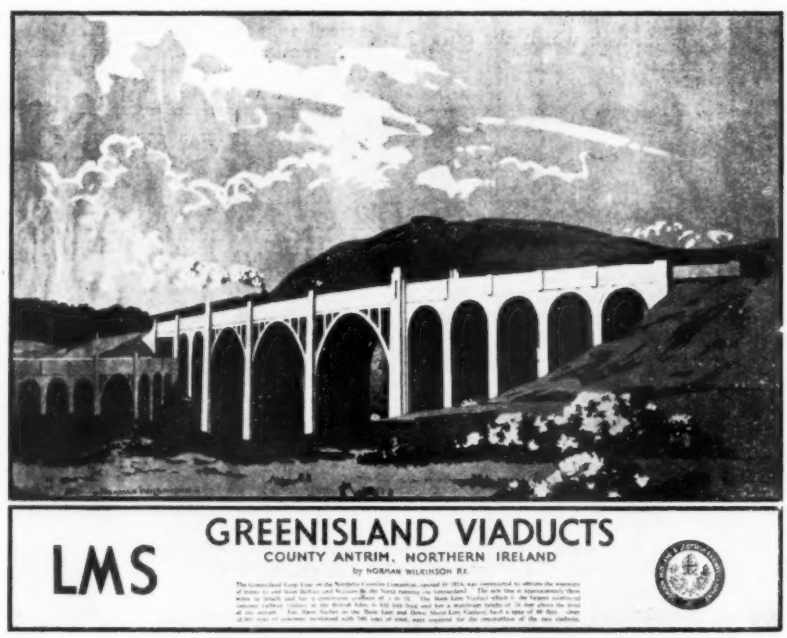
Garmisch Customs Station.—A customs office has been established in the railway station at Garmisch-Partenkirchen, Bavaria, for the benefit of visitors during the winter sports' season. This enables travellers to register their luggage straight through to Garmisch and so avoid opening up baggage at the frontier—a concession particularly welcome when, as so often happens, the frontier crossing is made at night.

Station Buildings Let to Visitors.—The Scottish Court of Session gave judgment on January 23 in rating appeals by the London & North Eastern Railway Company relating to Aberlady and Gullane stations, to which regular passenger traffic had ceased, but the line to which was still used for goods traffic. At these stations the line was used for occasional passenger traffic throughout the holiday season, at which period the company let furnished part of the passenger buildings, at a weekly rate, to visitors. The local Assessor had entered these stations on the local roll, and the Valuation Committee had sustained these entries on the ground that the passenger buildings were let out so as to be capable of separate assessment. Lord Hunter and the two other judges held that this view was clearly wrong as the Assessor entered the company as tenants and occupiers.

Railway Accident in Egypt.—A workmen's train from the new locomotive shops at Abu Zaabal to Cairo collided on January 31 with a stationary locomotive and seven persons were killed, including Mr. W. P. Ambler, of the locomotive works.

Further Tecalemit Extensions Planned.—Land adjoining the company's Brentford works has been acquired by Tecalemit Limited, the lubrication equipment maker, with a view to further extensions of the company's plant and factory space, which is expected to be set in hand shortly. The site acquired covers 5,000 sq. ft., making the total area of the site now owned approximately 110,000 sq. ft. The new programme is in addition to the building operations already in hand on which work began recently.

New L.M.S. Picture Poster.—The name of Mr. Norman Wilkinson, R.I., is attached to a large and finely-coloured poster now being exhibited on various L.M.S.R. hoardings. In this the massive nature of the Greenisland viaducts is well brought out and a passing train adds a realistic touch to the scene. In a letterpress section beneath, mention is made of the fact that the Greenisland loop line on the Northern Counties Committee, opened in 1934, was



Striking L.M.S. poster of the new Antrim loop viaducts

constructed to obviate the necessity of trains to and from Belfast and stations in the north running via Greenisland, and there reversing.

Gresham & Craven New Indian Works.—Gresham & Craven Limited, of London and Manchester, has decided to start a works in Calcutta for the manufacture of the vacuum brake, and for which the firm is to form an Indian company.

The Moscow Underground.—Press messages from Moscow state that on Monday last, February 4, the first test train traversed the eight miles now completed of the Moscow underground railway. This section, the first stage of the extensive proposed system described in our *Electric Railway Traction Supplement* dated October 19 last, is to be opened for public traffic shortly.

The G.W.R. Suburban Diesel Railcar Service.—On Monday last the G.W.R. streamlined diesel railcar completed its first year's running on the local services from Southall, during which time it has carried 136,000 passengers and run over 60,000 miles. The car has proved very popular, and many passengers make a journey for the purpose of travelling on the car.

City and Guilds College Jubilee.—The fiftieth anniversary of the foundation of the City and Guilds College was celebrated on Monday, February 4, in the presence of a large and distinguished company at the college in South Kensington. Guests were received by Lord Linlithgow, Chairman of the Governing Body of the Imperial College of Science and Technology, and by Mr. W. T. Prideaux, Chairman of the Delegacy of the City and Guilds College. In addition to Lord Linlithgow and Mr. Prideaux, Professor H. E. Armstrong spoke at the formal meeting following the reception.

Southern Railway Valuation for Rating.—The Railway & Canal Commission, on Wednesday, February 6, delivered judgment, which had been reserved on January 23, on the cross appeals by the Southern Railway Company and by local authorities against a decision of the Railway Assessment Authority that the valuation of the company's railway properties for rating purposes should be £2,180,000. It was contended by the railway company that the amount should not exceed £500,000, and by the local authorities that it should not be less than £3,000,000. The Court (Mr. Justice Mackinnon, Sir Francis Dunnell, and Sir Francis Taylor, K.C.), allowed the appeal of the railway company with costs against the Assessment Authority, reducing the valuation to £1,077,131, and dismissed the appeal of the local authorities with costs. Mr. Justice Mackinnon considered that the tenant's capital in this case should be valued at £27,610,690, and the 15 per cent. to be allowed on that for tenant's interest, profit and risk amounted to £4,141,608, to which had to be added a sum for the tenant's share of receipts earned without the use of his rolling stock. The total figure was £4,330,889, which, deducted from the agreed net receipts of £5,408,000, left £1,077,131 as the net annual value.

Dolserau Halt, G.W.R. — The G.W.R. new halt " Dolserau for the Torrent Walk " between Dolgelley and Bontnewydd, is to be opened to-day, February 8. Four up and three down trains will call daily, and cheap ticket facilities will be given to surrounding towns and villages on certain days of the week.

G.W. & L.M.S. Railways (Oxford) Dinner.—This annual dinner was held at the Randolph Hotel, Oxford, on Saturday, February 2, with Mr. Buckingham in the chair. A fine entertainment was enjoyed by all and some good speeches were heard. Among those present were Lord Eldon, Captain Bourne, M.P., Colonel A. H. Duke, and Mr. Barriball. Messages were received from Sir Felix J. C. Pole, Sir Harold Hartley, and Mr. Ralph Glynn.

L.M.S. Locomotive Depot Improvement Schemes.—A further 14 L.M.S.R. locomotive depots in various parts of England and Wales are to be modernised during the year and work is to be commenced forthwith. The depots concerned are Accrington, Agecroft, Bank Hall (Liverpool), Bedford, Bolton, Hasland (near Chesterfield), Holyhead, Lostock Hall (Lancs), Low Moor (Bradford), Lower Darwen, Mold Junction, Preston, Rose Grove (Lancs), and Tilbury (Essex). Included in these schemes is the provision of a mechanical coaling plant. With the exception of Holyhead, Tilbury and Hasland, mechanical ash-lifting plants for loading up engine ashes from the ashpits will also be installed. The layout of the locomotive yards will also be altered so as to provide facilities for the rapid disposal of engines after their arrival at the sheds.

Machine Tool Manufacturing.—Consequent upon the retirement of William Asquith Limited, Halifax, from participation in the sales organisation of Associated British Machine Tool Makers Limited, and the resultant amendment of its lines of manufacture, an agreement has been reached between Craven Bros. Ltd., Reddish, near Stockport, and William Asquith Limited, under which Asquith relinquishes making railway wheel turning lathes, tyre turning and boring lathes, axle centring, turning and ending lathes, and also the large centre lathes of various kinds for which the firm had been tendering ; and Craven will cease making various kinds of drilling and boring machines. Both firms expect the reduction in lines of manufacture to result in benefits which will be to the advantage of their clients. The arrangement will not interfere with the respective service and other facilities of the two companies in regard to machines already supplied by them. In our issue of November 9 last we recorded the retirement of Asquith from the A.B.M.T. as from November 7.

Questions in Parliament

Level Crossing Accidents

Mr. Thorne on February 4 asked the Minister of Transport if he had received a report in connection with the fatal accident at a level crossing near Grantham, when a train crashed into a baker's van; if he was aware that there had been an increase in accidents at level crossings; and what action he proposed to take in the matter.

Mr. G. D. Davies (a Lord of the Treasury) replied.—The number of accidents occurring annually at railway level crossings shows little or no tendency to increase. As regards the particular accident to which the hon. member refers, the Minister of Transport has appointed an officer to hold an inquiry, and will consider the matter further in the light of any recommendations he may make in his report.

Artisans on African Railways

Mr. McEntee on February 6 asked the Secretary of State for the Colonies whether his attention had been called to the cancellation of the agreements of a large number of Indian employees of the Kenya and Uganda Railways, whereby they lost all their preferential terms of employment and were placed on a daily wage system with no advantages whatever; how many artisan employees had been subjected to this change of employment methods; and when it was proposed to revert to the more equitable system of engagement which had hitherto existed.

Sir P. Cunliffe Lister. I am informed by the High Commissioner for Transport that 165 artisans in the lowest paid grades were given due notice of termination of their agreements and were offered and accepted re-engagement at daily rates of pay, with privilege of travel concessions and free medical attention in case of injury sustained on duty or attributable to the nature or locality of their employment. All these 165 artisans were locally engaged, except seven who were originally indentured from India. Return passages to India for these seven will be granted when required. All these artisans before being re-engaged were granted all the benefits and privileges that had accrued to them under the terms of service previously applicable. In addition to the 165 artisans referred to, 387 artisans have been engaged for the first time on the same conditions as those mentioned above. It is not intended to revert to the terms of service previously applicable to such servants, because (*a*) such conditions cannot economically be justified, (*b*) all artisans required can now be engaged locally on the present terms, (*c*) the present conditions are in line with those extended to corresponding labour employed by the Government, (*d*) the principle of employing such labour on daily rates of pay is followed on other large colonial railways.

British and Irish Traffic Returns

GREAT BRITAIN	Totals for 5th Week			Totals to Date		
	1935	1934	Inc. or Dec.	1935	1934	Inc. or Dec.
	£	£	£	£	£	£
L.M.S.R. (6,926 mls.)						
Passenger-train traffic...	355,000	354,000	+ 1,000	1,795,000	1,754,000	+ 41,000
Merchandise, &c. ...	437,000	445,000	— 8,000	2,110,000	2,142,000	— 32,000
Coal and coke ...	283,000	271,000	+ 12,000	1,339,000	1,351,000	— 12,000
Goods-train traffic ...	720,000	716,000	+ 4,000	3,449,000	3,493,000	— 44,000
Total receipts	1,075,000	1,070,000	+ 5,000	5,244,000	5,247,000	— 3,000
L.N.E.R. (6,339 mls.)						
Passenger-train traffic...	238,000	238,000	—	1,208,000	1,176,000	+ 32,000
Merchandise, &c. ...	303,000	318,000	— 15,000	1,518,000	1,551,000	— 33,000
Coal and coke ...	243,000	245,000	— 2,000	1,214,000	1,239,000	— 25,000
Goods-train traffic ...	546,000	563,000	— 17,000	2,732,000	2,790,000	— 58,000
Total receipts	784,000	801,000	— 17,000	3,940,000	3,966,000	— 26,000
G.W.R. (3,750¾ mls.)						
Passenger-train traffic...	150,000	145,000	+ 5,000	790,000	763,000	+ 27,000
Merchandise, &c. ...	181,000	176,000	+ 5,000	877,000	852,000	+ 25,000
Coal and coke ...	109,000	112,000	— 3,000	534,000	553,000	— 19,000
Goods-train traffic ...	290,000	288,000	+ 2,000	1,411,000	1,405,000	+ 6,000
Total receipts	440,000	433,000	+ 7,000	2,201,000	2,168,000	+ 33,000
S.R. (2,172 mls.)						
Passenger-train traffic...	227,000	222,000	+ 5,000	1,168,000	1,135,000	+ 33,000
Merchandise, &c. ...	60,500	65,500	— 5,000	277,000	297,000	— 20,000
Coal and coke ...	40,500	42,500	— 2,000	178,000	189,000	— 11,000
Goods-train traffic ...	101,000	108,000	— 7,000	455,000	486,000	— 31,000
Total receipts	328,000	330,000	— 2,000	1,623,000	1,621,000	+ 2,000
Liverpool Overhead ... (6¼ mls.)	1,065	1,060	+ 5	5,473	5,558	— 85
Mersey (4½ mls.) ...	4,180	4,357	— 177	21,480	21,965	— 485
*London Passenger Transport Board ...	508,200	507,200	+ 1,000	16,489,100	16,161,900	+ 327,200
IRELAND						
Belfast & C.D. (80 mls.) pass.	1,556	1,611	— 55	8,957	9,007	— 50
,, ,, goods	477	599	— 122	2,164	2,501	— 337
,, ,, total	2,033	2,210	— 177	11,121	11,508	— 387
Great Northern (543 mls.) pass.	7,500	7,450	+ 50	38,850	35,350	+ 3,500
,, ,, goods	9,550	9,500	+ 50	41,200	40,200	+ 1,000
,, ,, total	17,050	16,950	+ 100	80,050	75,550	+ 4,500
Great Southern (2,124 mls.) pass.	18,948	18,981	— 33	93,185	91,622	+ 1,563
,, ,, goods	40,925	34,508	+ 6,417	203,943	154,250	+ 49,693
,, ,, total	59,873	53,489	+ 6,384	297,128	245,872	+ 51,256

* 31st week, the receipts for which include those undertakings not absorbed by the L.P.T.B. in the corresponding period last year; last year's figures are, however, adjusted for comparative purposes

Forthcoming Events

Feb. 9 (*Sat.*)—Crewe Technical College Engineering Society. "The Application of Tapered Roller Bearings in Railway Service," by Mr. J. E. Spear.

L.N.E.R. (Great Central) Lecture and Debating Society, at Alderman Newton Boys' School, High Cross Street, Leicester, 5 p.m. "Electrical Arc Welding," by Mr. Carpenter.

Permanent Way Institution (Manchester-Liverpool) at Victoria Station, Manchester, 3 p.m. "Signalling," by Mr. J. W. Cocking.

Feb. 11 (*Mon.*).—Institute of Transport (London), at Inst. of Electrical Engineers, Savoy Place, W.C.2, 5.30 p.m. "Goods Shed Operations," by Mr. E. Falconer.

Permanent Way Institution (Brighton), in Lecture Room, New England Street, 7 p.m. "The Testing of Steel," by Mr. Treacher, Jnr.

Feb. 12 (*Tues.*).—Institute of Transport (Birmingham), at Queen's Hotel, 6 p.m. "The Problem of Traffic Congestion," by Mr. E. J. Beard.

L.N.E.R. (Middlesbrough) Lecture and Debating Society, at Cleveland Scientific and Technical Inst., Corporation Road, 7.15 p.m. "The New Regulations for Train Signalling," by Mr. F. Moiser.

Permanent Way Institution (Sheffield), at Royal Victoria Hotel, 7 p.m. "Continental Railways," by Mr. W. A. Willox.

Feb. 13 (*Wed.*).—Institute of Transport (Manchester-Liverpool Graduate), Grosvenor Hotel, Manchester, 6.30 p.m. "Alternatives to the Petrol Engine," by Mr. H. J. Hooley.

Institution of Welding Engineers (London), at Inst. of Marine Engineers, The Minories, E.C.3, 7.45 p.m. "Design and Testing of Welds," by Mr. C. W. Hamann.

Permanent Way Institution, in Staff Dining Room, Waterloo Station, 7 p.m. "Application of Arc Welding to Permanent Way Work," by Mr. J. P. M. Pannell.

Feb. 14 (*Thurs.*).—Institute of Metals (London), at Society of Motor Manufacturers, 83, Pall Mall, S.W.1, 7.30 p.m. "The Protection of Metals by Coatings," by Mr. W. H. J. Vernon.

Institution of Locomotive Engineers (London), at Inst. of Mechanical Engineers, Storey's Gate, S.W.1, 6 p.m. Informal.

L.N.E.R. (York) Lecture and Debating Society, at Railway Inst., Queen Street 7 p.m. Debate with Hull Society. "That the L.N.E.R. Company should Extend its Activities on the High Seas." *Affirmative:* Hull Society. *Negative:* York Society.

Railway Students' Association, at London School of Economics, Houghton Street, W.C.2, 6 p.m. "Railway Collection and Delivery Services," by Mr. A. E. Hammett.

Feb. 15 (*Fri.*).—Institute of Transport (Leeds Graduate), at Church Inst., Albion Place, 7 p.m. "Railway Organisation," by Mr. F. L. Hick.

Institute of Transport (London), at Connaught Rooms, W.C.2. Annual Dinner.

British and Irish Railways Stocks and Shares

Stocks	Highest 1934	Lowest 1934	Prices Feb. 6, 1935	Prices Rise/Fall
G.W.R.				
Cons. Ord. ...	66½	48½	53½	—
5% Con. Prefce. ...	118	109	119	—
5% Red.Pref.(1950)	115	107	116½	—
4% Deb.	117	105	116½	−1
4½% Deb.... ...	119	109	120½	+1
4½% Deb.... ...	129½	115¼	128½	—
5% Deb.	135	126¼	139½	—
2½% Deb.... ..	75	64	81½	—
5% Rt. Charge ...	134 7/16	123¼	134½	—
5% Cons. Guar. ...	132⅝	121⅝	134	—
L.M.S.R.				
Ord.	30½	19½	18½	−1
4% Prefce. (1923)	64¼	41	48	−1
4% Prefce. ...	87	69½	84½	−1½
5% Red. Prf. (1955)	107	92½	106	—
4% Deb.	114 1/8	100½	108	−1½
5% Red.Deb.(1952)	118 11/16	111¼	118½	—
4% Guar.	106½	96⅝	104½	−½
L.N.E.R.				
5% Pref. Ord. ...	24⅜	13½	12½	−⅜
Def. Ord.	11½	6⅞	6½	−⅜
4% First Prefce. ...	76	59½	68	−1½
4% Second Prefce.	47	25½	26	−1½
5% Red.Pref.(1955)	94½	80	89½	−2
4% First Guar. ...	104	92	101	−1
4% Second Guar.	97⅞	86½	95½	−1½
3% Deb.	90	74½	83½	−2
4% Deb.	114	99¼	107	−2
5% Red.Deb.(1947)	117	108	117	—
4½% Sinking Fund Red. Deb.	111¼	105¼	110½	—
SOUTHERN				
Pref. Ord.... ...	90	63⅛	80	−1
Def. Ord.	32⅝	19	20	−½
5% Prefce. ...	118 3/16	107½	119½	—
5% Red.Pref.(1964)	115¾	107½	116½	—
5% Guar. Prefce.	132	120¾	133½	—
5% Red.Guar.Pref. (1957)	119½	113	120½	+½
4% Deb.	116½	103¼	115½	−½
5% Deb.	134	124 15/16	134½	—
4% Red. Deb. 1962–67	113 11/16	105 9/16	114	+⅝
BELFAST & C.D.				
Ord.	6	5	5¼	—
FORTH BRIDGE				
4% Deb.	110	100	109½	—
4% Guar. ...	110	100	109½	—
G. NORTHERN (IRELAND)				
Ord.	9¾	4 15/16	10	+3
G. SOUTHERN (IRELAND)				
Ord.	25	12½	24½	+1
Prefce.	21½	13 15/16	26¼	+1
Guar.	48	39	58	+½
Deb.	67	59	75½	−3½
L.P.T.B.				
4½% "A" ...	126	115	128½	—
5% "A"	135½	124½	138½	—
4½% "T.F.A." ...	113½	107½	113	—
5% "B"	131¾	118	130½	—
"C"	97	73	94	+2
MERSEY				
Ord.	15¼	7	14*	—
4% Perp. Deb. ...	93½	82½	93½	—
3% Perp. Deb. ...	66½	61½	68½	+1
3% Perp. Prefce....	54	44½	51½*	+2

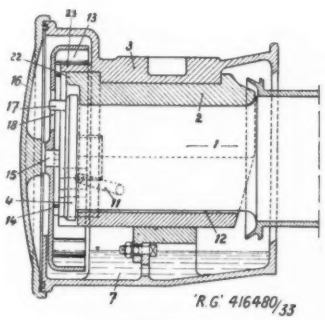
* ex dividend

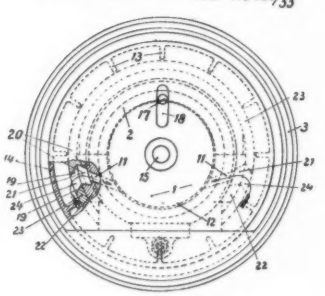
ABSTRACTS OF RECENT PATENTS

No. 416,480. Axle Bearings

E. F. Matthews, of Elm Cottage, Watford Road, Wembley, Middlesex. February 8, 1933.

In lubricating axle bearings, the lubricant, which is continually elevated by the rotation of the axle-journal, is supplied as a jet to the axle-journal by means which act dynamically, the jet passing on to the axle-journal across a wedge-shaped space which exists between the latter and the fixed bearing brass. 1 is the axle-journal, 2 the annular brass and 3 the casing, the bore of the brass 2 being so dimensioned in relation to the axle-journal that a wedge-shaped space 12 is formed between the two parts. Passages 11 in the annular brass 2 open into this space 12 and are joined up with recesses 21 in the corbelling 22 of the brass 2. The corbelling 22 is surrounded by an annular ledge 23 on the casing, this ledge having recesses 24 opposite the specially formed recesses



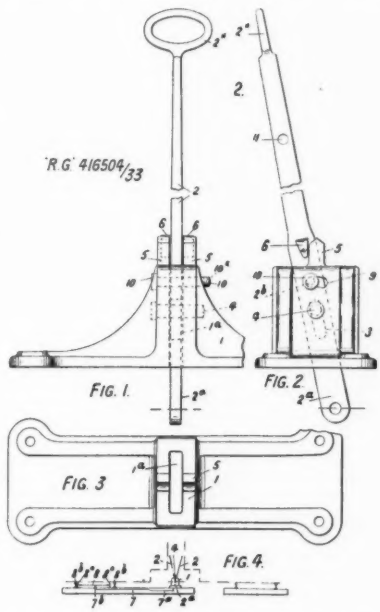


21. The walls 19 and 20, which form the recesses 21 and 24, are shaped so that the upwardly conveyed lubricant receives an impulse as it enters the passages. The conveyor member is a cup-shaped disc 14 having throwing surfaces 13 and rotates about a guide ring 23. This disc 14 is rotatably mounted on a pin 15 which is rigidly connected with the cover 16 of the casing 3. A conveyor pin 17, fixed to the collar 4 of the axle-journal, slides in a slit like recess 18 in the cup-shaped disc 14 and effects the constant rotation of the disc during the rotation of the axle-journal. The apparatus operates as follows: the surfaces 13, which dip into the lubricant reservoir 7, throw the lubricant which is taken up and collected with great force into the recesses 24. The jet of lubricant thus formed enters the wedge-shaped space 12 and passes on to the axle-journal. — (*Accepted September* 10, 1934.)

No. 416,504. Switch-operating Mechanism

The Monarch Door Controller Co. Ltd., of 7, *Victoria Street, London, S.W.*1, *J. G. B. Sams, of "Westleys," Wimbish, Saffron Walden, Essex, and G. W. Smith, of* 6, *Grosvenor Mansions, Buxton, Derbyshire. March* 17, 1933.

A railway switch-operating mechanism comprises a slotted lever-box 1 adapted to be secured to sleepers or other support and provided with a vertical radial slot 1^a within which an operating hand lever 2 is mounted to turn in a to and fro direction. The lever 2 is formed with a slot 3 through which extends a pivot pin 4 carried by the lever-box 1 and about which the lever can be turned. The lever box 1 is provided, at each side of the slot 1^a therein, with a centrally arranged abutment in the form of an upwardly extending projection 5, and the lever 2 is formed on its opposite sides with two wedge-shaped projections 6 adapted to bear against one or other side of the projections 5. The lower end 2^a of the lever 2 is jointed to one end 7^a of a connecting rod 7 (Fig. 4), the other end of which is jointed at 7^b to a traversing rod 8 connecting the two rail switches 8^a 8^b are the stock rails with which the switches 8^a are associated. The lower end of the lever 2 is connected to the switches 8^a by the rod 7 so that the projection 6 will be held firmly against one side of the projections 5 so as to be above the top of the lever-box 1 and with the top of the slot 3 in the lever above the top of the pivot pin 4. The lever 2 is provided with a handle 2^* to enable it to be lifted and then turned about the pivot pin 4. When connecting the two rail switches 8^a. into the opposite position, the lever 2 is lifted to free the projections 6 from the projections 5 and then turned in the slot 1^a in the lever-box and about the pivot pin 4 from its original switch holding positions to its opposite switch holding position and then allowed to drop, its projections 6 being thereby caused to bear against the opposite sides of the projections 5 so as to hold the switches 8^a firmly in their new position relatively to the stock rails 8^b. By arranging the switch operating mechanism so that the movement of the lever 2 is in a plane at



right angles to the track, stock rails and switches, as shown in Fig. 4, instead of parallel thereto, the use with the rodding 7 of a bell crank with its consequent lost motion and complication is avoided. The lever-box 1 is provided between the pivot pin 4 and the projections 5 with a curved slot 9 through which and a hole 2^b in the lever 2, a headed locking pin 10 can be passed so as to prevent the lever being raised and turned when it is desired to put the switch operating mechanism out of use for a time.—(*Accepted September* 17, 1934.)

No. 416,714. Locomotives

J. Kupka, of 5, *Woodstock Road, Chiswick, London, W.*4. *January* 18, 1933.

In an articulated locomotive having a transmission shaft passing axially through the articulation to convey motion from a prime mover carried on one undercarriage to a wheel axle on which another undercarriage is mounted, the transmission shaft is movable axially in a gear wheel by which it is rotated and is connected by a universal joint to a coupling shaft transmitting motion to the driving wheels. 5 is an undercarriage having a boiler 6 mounted thereon and a number of cylinders 7 (as shown in Fig. 2), each having a piston 8 movable therein with a piston rod 9 connected to a crosshead 10 and a connecting rod 11 for actuating a corresponding crank 12 formed in a crank

* These abridgments of recently published specifications are specially compiled for THE RAILWAY GAZETTE by permission of the Controllor of His Majesty's Stationery Office. Group abridgments can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, either sheet by sheet as issued, on payment of a subscription of 5s. a group volume, or in bound volumes, price 2s. each, and the full specifications can be obtained from the same address price 1s. each.

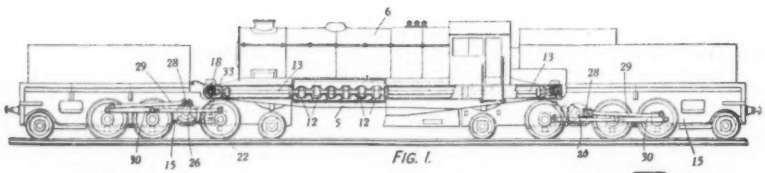


FIG. 1.

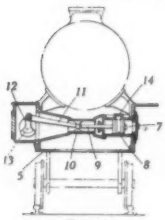


FIG. 2.

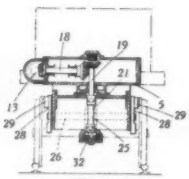


FIG. 3.

'R.G.' 416714/33

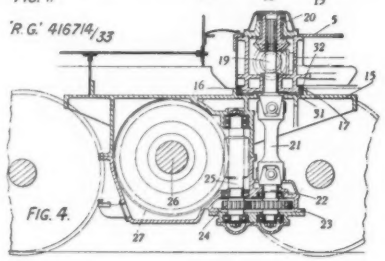


FIG. 4.

shaft 13 extending along one side of the undercarriage opposite to that on which the cylinders 7 are mounted with the crossheads 10 below the boiler 6. The undercarriage 5 is supported by its ends resting on the frames 15 of the driving wheel units, an articulated connection being made (Fig. 4) by a member 16 of the undercarriage 5 seated in a cup 17 on the frame 15. The crank shaft 13 extends the whole length of the undercarriage 5 and is geared at each end through a transverse shaft 18 to a vertical transmission shaft 19. The latter is slidable axially in a bevel wheel 20 by which it is driven and is connected through a universal joint coupling shaft 21 to a pinion shaft 22 carrying a gear wheel 23. The latter is in gear with a wheel 24 on a worm shaft 25 mounted in bearings carried by the frame 15, which also carries a jack shaft 26 with a worm wheel 27 driven by the worm when the crank shaft 13 is rotated by the engine comprising the cylinders 7. The jack shaft 26 is provided at its ends with cranks 28 coupled by connecting rods 29 to rods 30 coupling the driven wheels of the driving wheel unit 15. A wear plate 31 and liner 32 are provided to take up wear between the member 16 and cup 17 and to maintain these parts concentric one with the other.—(*Accepted September* 18, 1934.)

No. 416,897. Locomotives

Aktiebolaget Ljungströms Ängturbin, of 32, *Kungsgatan, Stockholm, Sweden. February* 22, 1934. (*Convention Date: February* 23, 1933.)

In a turbine locomotive having a toothed gearing for the transmission of the turbine output to the locomotive driving wheels, the gearing is divided into two stages enclosed in casings separated from each other and arranged so that the one stage, comprising the fast running gear shaft, is mounted on the one side of the locomotive opposite to the forwards turbine located on the other side of the latter, whereas the other secondary stage, which comprises the slow running gearing, is fitted between the driving wheels. 1 is the boiler, 3 the driving axle with its driving wheels 4 rigidly secured thereto, and 5 is the casing of the end gear wheel 9, on the hub of which is laterally mounted a fork lever 6. The latter is connected, by movable intermediate members, to a corresponding fork lever 6' rigidly fixed on the driving axle 3. 7 is the casing of the forwards turbine and 8 a combination casing, located on the other side of the turbine, in which casing are housed a backwards turbine, a reduction gearing therefor and the primary stage of the gearing. The end gear wheel 9, (Fig. 2), is in connection with the fork lever 6. The forwards turbine 10 (Fig. 3) operates on the main shaft 14 of the primary gear part 8 through an intermediate shaft 11 and resilient discs 12. Mounted on the shaft 14 is a double pinion 15 co-operating with two pairs of intermediate wheels 16 and 17 keyed to the shafts 18 and 19, respectively, pinions 20 and 21, respectively, being mounted on the other ends of said shafts and work on a common intermediate wheel 22 which is in engagement with the end gear wheel 9. The faster running wheels 15, 16, 17 form the primary stage and the slower running wheels 20, 21, 22, 9 form the secondary stage of the gearing. Located in the casing of the primary stage is the backwards turbine 23, which may work on the shaft 14 with the aid of a reduction gearing 24 and 25 and a coupling (not shown) when the forwards turbine is cut off.—(*Accepted September* 24, 1934.)

No. 417,100. Turbo-Feed Pump for Locomotives

The British Thomson-Houston Co. Ltd., of Crown House, Aldwych, London, W.C.2. March 13, 1934. (*Convention Date: March* 14, 1933.)

A turbo feed pump comprises a steam turbine and centrifugal pump mounted on a common shaft between two outside bearings without an intermediate bearing and the turbine and pump casing are divided vertically and are undivided horizontally, so that a lateral erection and dismantling of the individual parts of both the turbine and the pump is rendered possible. *a* is the centrifugal pump which is loaded at both sides, and *b* the single-ring turbine impeller, which in order more advantageously to utilise the speed of

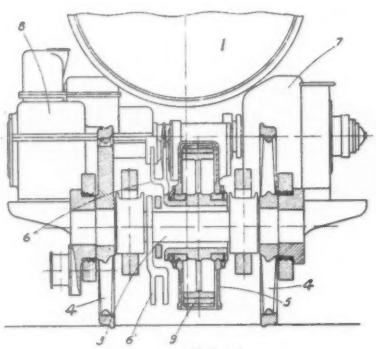


FIG. 2.

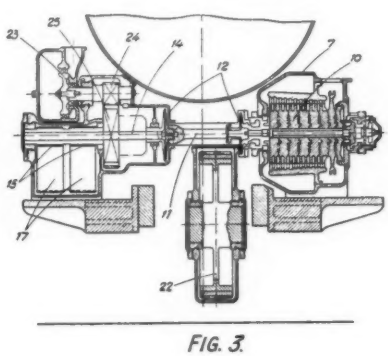


FIG. 3.

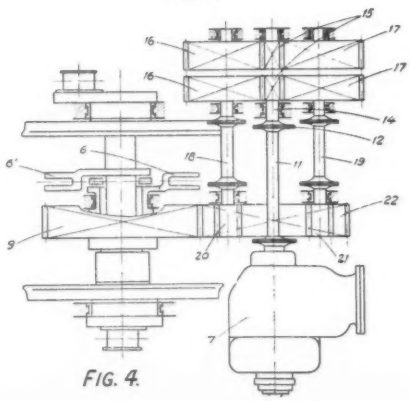


FIG. 4.

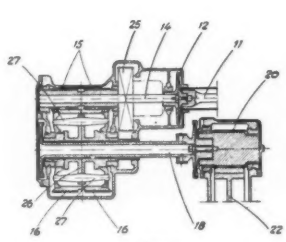
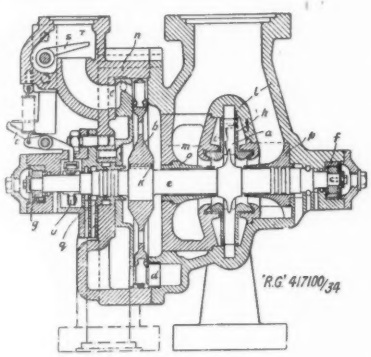


FIG. 5.

'R.G.' 416897/34

the steam delivered by the nozzles *c*, is again loaded with steam after the reversal of the direction of the steam by the reversing vanes *d*. The turbine impeller wheel *b* and pump wheel *a* are mounted on a common shaft *e*, which is supported in the two bearings *f* and *g*. The blades of the pump wheel

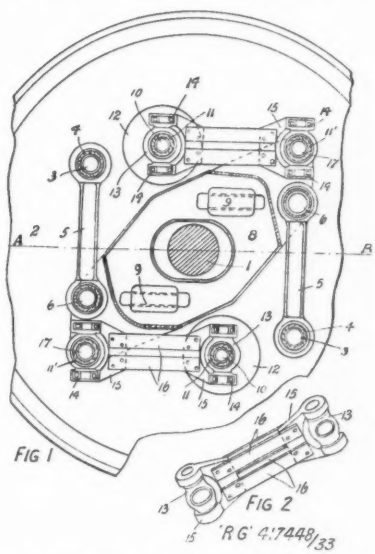


are fitted into the boss of the wheel, made in one piece with the shaft, and are closed laterally by the two covering discs *h* and *i* against the pressure chambers of the device. The turbine wheel *b* is connected to the shaft *e* by round keys *k*. The casing of the combined machine consists of the parts *l*, *m*, *n*, of which the casing members *l* and *n* enclose the pump and the turbine whilst the part *m* forms the partition wall between turbine and pump and simultaneously the admission body for the one side of the pump. The pump casing consisting of the parts *l* and *m* simultaneously forms a part of the turbine casing at the turbine side. All parts of the casing are undivided in the horizontal direction and are so dimensioned that the inner parts can be removed laterally. Turbine and pump are sealed against each other by the intermediate stuffing-box *o*. The penetration of air into the pump or into the interior of the turbine is prevented by the outer stuffing-boxes *p* and *q*. In the steam feed-pipe *r* of the turbine *b* there is provided a quick-closing valve *s*, which is held open by a pawl *t* during the ordinary working of the machine, but on the occurrence of excessive speed is released by a safety regulator *u* and is closed by the flow of steam or the steam pressure.—(*Accepted September* 27, 1934.)

No. 417,448. Drives for Electric Locomotives

The British Thomson-Houston Co. Ltd., of Crown House, Aldwych, London, W.C.2. March 1, 1933. (*Convention date: March* 1, 1932.)

In a driving system for electrically propelled locomotives, the stresses of the motor shaft are transmitted to the wheels by means of links, some or all of which are flexibly constructed and are provided with ball or roller bearings at their points of articulation. On the wheel 2 usually fixed to the axle 1 are fixed two journals 3 which carry the inner rings of roller bearings 4, the outer rings of which are carried by the heads of simple links 5. Two shafts 6 passing through the forked ends 7 of a plate 8 receive the inner rings of another bearing. The plate 8 is kept parallel with the wheel by means of flanged guides 9 which project through slots in the plate and are mounted on the wheel. The lots are of such a size that the plate 8 can move to a limited extent provided it remains parallel with the wheel 2. A transmitting member driven by the motor shaft carries two journals 10 supporting the inner rings of the bearings 11. Openings 12 are provided in the wheel for the passage and fitting of the journals 11. A complete link illustrated more in detail in Fig. 3 mounted on the cardan shaft at each of its extremities is made up as follows: two members 13 with journals receive in the centre the outer rings of the bearings 11—11¹ and on each of their journals the inner rings of bearings 14. These heads are rigidly connected together by four steel blades 16 of rectangular section. Two shafts 17 receive the inner rings of the bearings 11¹ and connect these links to the forks



7 of the plate 8. If the wheel, placed with its axis AB horizontal, ascends or descends, its journals 3 act, through the links 5, to move the plate 8 and the shafts 17 of the cardan links. The latter tip to the extent required by pivoting on the bearings 11¹ and about the shafts 17. If on the contrary the axis AB is vertical, the journals 3 ascend or descend and the links 5 tip by pivoting on the bearings 4 and about the shafts 6. If the axis AB is placed in an intermediate position, these two movements are combined. When the wheel is displaced in the longitudinal direction of the axle, it carries with it the plate 8 and, as the members 13 dependent on the transmitting member have not moved, the composite links 15, 16 tip by pivoting on their bearings 14.—(*Accepted October* 1, 1934.)

COMPLETE SPECIFICATIONS ACCEPTED

415,050. Railway-coach seat. Beresford, K.

415,157. Indiarubber rolling packing rings. Spencer Moulton & Co. Ltd., G., and Spencer, J. C.

415,229. Metal railway chairs and sleepers. United Steel Companies Limited and Mason, B. G.

415,375. Fastenings for securing railway rails to metal sleepers. Mills Limited, Executors of J., and Macbeth, A.

415,390. Steam superheater elements. Superheater Co. Ltd. and Hall, F.

415,420. Tipping apparatus for railway trucks and the like. Gothaer Waggonfabrik Akt. Ges.

415,517. Water-tube boilers. Thompson Water Tube Boilers Limited, J., and Plummer, G. A.

415,552. Crossings for railway or tramway track. Summerson & Sons Limited, T., and Wrightson, S. S.

415,705. Road vehicles, rail vehicles, and the like, applicable also to conveyors. Fisher, G. L., and Bright & Galbraith Limited.

415,743. Road and rail vehicle construction. Dehn, F. B. (Tatra Works Limited).

416,088. Dynamos for train-lighting installations. Stone & Co. Ltd., J., and Chilton, A. H.

416,117. Railway level-crossing signals. Naamlooze Vennootschap Machinerieen-en Apparaten Fabrieken.

416,328. Overhead current collector gear for electric locomotives and the like. English Electric Co. Ltd., and Mardis P.L., and Wood, H. B.

416,394. Pantograph current collectors for electric locomotives and the like. English Electric Co. Ltd., and Wood, H. B.

416,445. Buffers for stopping railway vehicles. Ransomes & Rapier Limited, and Bowtell, W. J.

416,459. Transmission of line signals to a moving train. Burgess, A. F.

416,471. Means for transporting railway vehicles by road. Gothaer Waggonfabrik Akt. Ges.

416,641. Draw-bar and buffing-gear for railway and like vehicles. Krupp Akt. Ges., F.

416,652. Railway signalling apparatus. Brooker, A. W., and Tyer & Co. Ltd.

416,669. Steam power systems embodying compound or multi-expansion steam engines. Sentinel Waggon Works Limited, and Doble, A.

416,793. Boiler and like tube-cleaning apparatus. Thomas, W. P.

416,794. Boiler and like tube-cleaning apparatus. Thomas, W. P.

416,907. Means for transporting railway vehicles by road. Gothaer Waggonfabrik Akt. Ges.

416,959. Signal-lamp apparatus, more particularly for use on railways. Corning Glass Works.

417,082. Automatic coupling-devices for vehicles. Burgess, A. F.

417,099. Gas-illuminated railway signals. Naamlooze Vennootschap Machinerieen-en Apparaten Fabrieken.

417,156. Buffing and draught gear for railway vehicles. Spencer Moulton & Co. Ltd., G., and Glascodine, R. T.

417,264. Apparatus for controlling traffic, more particularly on single-line railways. Couper, J. D. C.

XUM

CONTRACTS AND TENDERS

Kendall & Gent (1920) Limited has received an order for two portable cylinder-boring machines and one portable piston-valve liner boring machine for the Bengal–Nagpur Railway.

Gresham & Craven Limited, of London and Manchester, has decided to start a works in Calcutta for the manufacture of the vacuum brake, and for which the firm is to form an Indian company.

The Great Western Railway has placed orders with Scammell Lorries Limited for 26 3-ton mechanical horses, and with the Principality Wagon Co. Ltd. for seven movable floor bodies. Fifty-two 3-ton and 16 6-ton trailers are also being added to the company's road transport fleet.

Diesel Railcars for South America

The Birmingham Railway Carriage & Wagon Co. Ltd. has received an order from the Central Argentine Railway for two twin-articulated and four single unit diesel-mechanical railcars, each fitted with a new type of Armstrong-Sulzer engine developing 275-b.h.p. at 1,150 r.p.m. and 290 b.h.p. at 1,200 r.p.m. Two of the single cars and the two articulated cars will be fitted with S.L.M. mechanical transmission and the remaining two single cars will be fitted with a Vulcan-Sinclair hydraulic coupling and Wilson pre-selective epicyclic gearbox. One each of the single cars fitted respectively with the Wilson and the S.L.M. gear will have the Electro Magnetic Brake Company's design of radial arm axlebox. Roller bearings will be used throughout for the axleboxes and Girling drum brakes will be employed. J. Stone & Co's pressure ventilation, heating and lighting systems will be used. The single cars will accommodate 75 passengers, and the double cars 149 passengers, all one class in each case. The cars will be semi-streamlined with aluminium-panelled bodies, and luggage and lavatory compartments are provided in each design. The interior finish of the cars will be in Rexine.

The L.M.S.R. has placed contracts with a London firm for the reconstruction of West Street bridge at Gravesend, where the company owns the Gravesend-Tilbury ferry pier, and with a Watford firm for the rebuilding of the station frontage at Wembley, which contract forms part of a scheme for enlarging and improving Wembley station.

Geo. Sheffield & Co. Ltd. has received an order for 400 Framwel axleboxes to be fitted to the Sheffield-Twinberrow bogies on the 50 3-ft. 6-in.-gauge bogie open cattle wagons which, as announced in this column of our January 25 issue, the Birmingham Railway Carriage & Wagon Co. Ltd. has on order from the Crown Agents for the Colonies for service on the Nigerian Government Railways.

R. Y. Pickering & Co. Ltd. has received orders from the Bengal-Nagpur Railway for 500 carriage and wagon drawbars and 200 disc-centred wagon wheels.

R. Y. Pickering & Co. Ltd. has also received an order from the Bhavnagar State Railway for 22 pairs of wrought-iron-spoked wheels and axles for 2 ft. 6 in. gauge track to the inspection of the consulting engineers, Messrs. Robt. White & Partners.

New Suburban Trains for L.N.E.R.

The L.N.E.R. has placed orders for a total of 96 suburban coaches for the Great Eastern section, divided as follow :—

Craven's Railway Carriage & Wagon Co. Ltd.: 24 second class and 12 brake-third class coaches.
R. Y. Pickering & Co. Ltd.: 24 third class and 12 brake-third class coaches.
Gloucester Railway Carriage & Wagon Co. Ltd.: 24 composite coaches.

These vehicles will be made up into 12 set trains each of eight coaches. It will be recalled that, as announced in our issue of January 11, the L.N.E.R. proposed to add four eight-coach sets for service on this section during 1935, and the number has since been increased to 12 sets as now ordered.

The tender of the Metropolitan-Cammell Carriage & Wagon Co. Ltd. has been accepted provisionally by the Swansea Corporation Electricity Committee for 30 20-ton wagons for the handling of anthracite duff, states *The Daily Express*.

Leyland Motors Limited has received the following orders from railway-associated road transport operators: East Midland Motor Services Limited, six oil-engined Titans and nine oil-engined Tigers; Western Welsh Omnibus Co. Ltd., 44 oil-engined Tigers; Hebble Motor Services Limited, six oil-engined Titans; East Yorkshire Motor Services Limited, six Titans and 10 Tigers; and Yorkshire Traction Co. Ltd., 35 oil-engined Tigers.

The Egyptian State Railways Administration has placed orders as follow :—

W. F. Dennis & Co.: Wire. (Total price, £256 7s. 6d.; ref. E.S.R. 5.55.)
A.E.G. Electric Co. Ltd.: Cables. (Total price, £220; ref. E.S.R. 30.123.)
Thos. Firth & John Brown Limited: Engine tyres. (Total price, £444; order No. 21.233.)
Hugh Gordon & Co.: Brass and copper. (Total price, £374 13s. 10d.; order No. 6.100.)
N.V. Nederlandische Kabelfabriek: Copper wire. (Total price, £1,046 5s.; ref. No. E.S.R. 30.113.)
Columeta Export Co. Ltd.: Galvanised-iron wire. (Total price, £1,288 18s. 5d.; ref. No. E.S.R. 30.114.)
Bochumer Verein für Gubsthlfabrikation: Tyres. (Total cost, £570 7s. 6d.; ref. No. E.S.R. 21.229.)

The Deutsche Werft Aktiengesellschaft has received an order from the Argentine Ministry of Public Works for three diesel-engined ferry-boats for transporting passengers and vehicles between the river ports of Victoria (Entre Rios), and Rosario de Santa Fe; and Puerto Constanza and Zarate. Each vessel is to be fitted with two 300-h.p. diesel motors, and by the terms of the contract delivery is to take place eight, nine and ten months respectively after acceptance of the tender.

The South African Railways & Harbours Administration has placed the following orders :—Guest Keen & Nettlefolds Limited: Gauge clips (Order No. B6597/1, total price £2,272 18s. 4d.) and bolts with nuts and spring washers (Order No. B6597/2, total price £3,050); and Waterlow & Sons Limited: Ticket cards (Order No. A7484, total price £272 13s. 4d.).

The Bengal-Nagpur Railway Administration has placed the following orders:

United Steel Co. (India) Ltd.: 79 tons flat iron bar at total cost of Rs. 17,281.14 and 78 tons spring steel at total cost of Rs. 14,137.8, and 27 tons round mild steel at total cost of Rs. 10,074.6.
Heatly & Gresham Ltd.: 31 tons mild steel at total cost of Rs. 11,566.14.
Dorman Long & Co. Ltd.: 298 tons mild steel plate at total cost of Rs. 37,622.8.
Martin & Co. Ltd.: 210 tons mild steel sheet at total cost of Rs. 27,825.
Jessop & Co. Ltd.: 73 tons spring steel at total cost of Rs. 13,231.4.

Swedish Rail Material for Persia

The exchange of commercial products between Sweden and Persia, started some years ago and carried on in collaboration with Kooperativa Foerbundet, Persiska Kompaniet and other concerns, has proved a success, and fresh good results have just been published, states Reuters. The locomotive and wagon works of Nydqvist and Holm A./B. at Trollhättan have obtained an order for railway material for Persia valued at Kr. 5,500,000. This order will give the Swedish works employment for some 18 months. Swedish firms are also busy in Persia on railway and road constructions and have just obtained a contract with the Persian Government for bridges to the value of some Kr. 4,000,000. The goods ordered from Nydqvist and Holm A./B. at Trollhättan are to be delivered in the course of 1936 and consist of a large quantity of different materials, including 12 very big steam locomotives of 140 tons each, powerful diesel-electric motor cars, some hundreds of goods trucks, passenger coaches and special material. The commercial exchange with Persia is based on the barter principle.

The L.N.E.R. announces the carrying out of alterations and improvements to the North engine shed at York. The scheme includes the lengthening of a number of stalls inside the shed and the replacement of the existing 60-ft. turntable by one of 70-ft. dimension. The alterations are being carried out primarily to afford improved facilities for handling large engines of the Pacific type.

The L.N.E.R. also announces that a 10-h.p. electric vacuum cleaning plant is to be installed at Bounds Green carriage sidings, Wood Green, to enable the interiors of main line and suburban trains to be cleaned more efficiently and quickly. Portable hand vacuum cleaners are already in use at King's Cross and Hornsey, and there is a larger cleaning plant at Finsbury Park operated by two men, but the new plant will be of the latest design arranged so that six compartments can be cleaned simultaneously. The vacuum cleaning equipment will be installed adjacent to the

OFFICIAL NOTICES

South Indian Railway Company Limited

THE Directors are prepared to receive Tenders for the supply of :—

1. 7 Locomotive Boilers (Metre Gauge).
2. Paint Brushes.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company Limited, marked "Tender for Locomotive Boilers," or as the case may be, with the name of the firm tendering, must be left with the undersigned not later than 12 NOON on Friday, the 1st March, 1935, in respect of Specification No. 1, and not later than 12 NOON on Friday, the 15th February, 1935, in respect of Specification No. 2.

The Directors do not bind themselves to accept the lowest or any tender.

A charge, which will not be returned, will be made of £1 for each copy of Specification No. 1, and of 5s. for each copy of Specification No. 2.

Copies of the drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White & Partners, 3, Victoria Street, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W.1.
6th February, 1935.

THE Proprietors of British Patent No. 285,466 are prepared to sell the Patent or to licence British manufacturers to work thereunder. It relates to flexible staybolts for fire boxes of locomotive and other boilers.—Address : BOULT, WADE & TENNANT, 111/112, Hatton Garden, London, E.C.1.

PATENTS for Inventions, Trade Marks, Advice, Handbook, and consultations free. King's Patent Agency, Ltd. (B. T. King, C.I.M.E., Registered Patent Agent, G.B., U.S., and Canada), 146A, Queen Victoria Street, London, E.C.4. 49 years' references. 'Phone City 6161.

automatic carriage washing plant, so that passenger coaches will be thoroughly cleansed inside and outside as they pass through the sidings.

William Beardmore & Co. Ltd. has received orders from the Bengal-Nagpur Railway for 984 engine and tender tyres, and 1,400 carriage and wagon tyres.

Geo. Turton Platts & Co. Ltd. has received an order from the Indian Stores Department for 700 buffer shanks at a total price of Rs. 13,300 free delivery.

Samuel Osborn & Co. Ltd. has received an order from the Indian Stores Department for 50,000 steel rail keys at a total price of Rs. 11,000 free delivery.

The Monkbridge Iron & Steel Co. Ltd. has received an order for carriage and wagon axles for the Bengal-Nagpur Railway.

The Yorkshire Copper Works Limited, through Macbeth Bros. & Co. Ltd., has received orders from the Great Indian Peninsula Railway for a total 195 cwt. of copper tubes for locomotives.

A. Butterworth & Co. Ltd. has received an order for two automatic screwing machines for the Bengal–Nagpur Railway.

Henry Pels & Co. Ltd., through Alfred Herbert (India) Limited, has received an order from the East Indian Railway for one Pels-type Lg 300/3,000 multiple punching machine arranged for motor drive and complete with electrical equipment and spares, at a total price of Rs. 30,805.

The Indian Stores Department has recently placed the following orders :—

Richardson & Cruddas Limited : 50,000 gal. tank and staging at total price of Rs. 12,790.

Greaves Cotton & Co. Ltd. : one 200-b.h.p. crude oil engine at total price of Rs. 41,256.

Balmer Lawrie & Co. Ltd. : 2,900 cwt. of galvanised tin sheets at total price of Rs. 28,547.

G. D. Peters (India) Limited : 10,000 mild steel cotters at total price of Rs. 12.188.

Hagener Federnfabrik has received an order from the Bengal-Nagpur Railway for approximately 6,000 volute springs, and Stahlunion Export an order for approximately 3,000 spiral springs.

The South Indian Railway has placed orders to the inspection of the consulting engineers, Messrs. Robt. White & Partners, as follow :—J. Stone & Co. Ltd. : Locomotive headlight equipment, excluding head lamps and generators, and spare parts for train-lighting dynamos ; Morgan Crucible Co. Ltd. : Spare parts for Morgan furnaces ; S. A. Boulonneries du Ruau : 60 tons of dog-spikes : Thos. Firth & John Brown Limited : 594 steel locomotive tyres and 1,700 steel carriage and wagon tyres ; Vulcan Foundry Co. Ltd. : Crank and straight locomotive axles ; and A.B.C. Coupler & Engineering Co. Ltd. : Flexible buffers for locomotives.

Tenders are invited by the Agent, G.I.P. Railway, Bombay, receivable by February 27, for sling chains for a 35-ton travelling steam crane.

Alfol Insulation Limited has secured an order for complete sets of Alfol insulation for the 100 two-cylinder 4-6-0 locomotives which, as announced in this column in our September 7, 1934, issue, Sir W. G. Armstrong, Whitworth & Co. (Engineers) Ltd. has in hand for the L.M.S.R.

Tenders are invited by the North Western Railway of India, Lahore, receivable by March 5, for the supply of 116,000 steel sleepers. Tenders are also invited, receivable by March 20, for the supply of 770 sets of combination fishplates to be supplied between May 1 and August 31.

The Chief Controller of Stores, Indian Stores Department, New Delhi, invites tenders receivable by February 25 for the supply of rubber and metallic vacuum brake fittings to the E.I., E.B., N.W., G.I.P., and Burma Railways on a running contract basis during June 1, 1935—May 31, 1936. Tenders are also invited, receivable by February 21, for 2,600 boiler tubes required for the Eastern Bengal Railway and, receivable by March 7, for a total of 3,065,000 mild steel dogspikes for the North Western Railway of India, during the period April 1 to September 30, 1935.

In addition to the 2,050 four-wheeled goods wagons, without wheels and axles, for broad-gauge service for which, as recorded in last week's issue, the Indian Railway Board has issued enquiries, a further 2,200 broad-gauge four-wheeled covered wagons without wheels and axles, comprising 1,130 type CR and 1,070 type CMR, are being enquired for, for construction in India. Tenders are due on March 11 at New Delhi.

Railway and Other Reports

Birmingham Railway Carriage & Wagon Co. Ltd.—The directors have resolved to transfer £87,500 from reserve to profit and loss, giving an available balance of £98,371, and leaving £350,000 in the reserve. They recommend a dividend of 5 per cent. less tax, on the ordinary shares for the year 1934 (the same as for 1933), and a half year's dividend on the preference shares, leaving £57,646 to be carried forward, as against £30,645 brought in. For 1933 the net profit was £17,504.

Tilling & British Automobile Traction Limited.—A final dividend is recommended of 5 per cent. (against 6 per cent.), making 10 per cent. (the same) on the ordinary shares Nos. 1 to 2,000,000 for the year 1934. This payment again entitles the 8 per cent. preference shares to an extra dividend of 2 per cent. A dividend of 5 per cent. for the half-year ended December 31, 1934, is also to be paid on the bonus ordinary shares Nos. 2,000,001 to 2,500,000 (which rank for dividend from July 1, 1934). This company, jointly with the appropriate main line railways, controls many provincial omnibus undertakings.

National Omnibus & Transport Co. Ltd.—This company is controlled by Thomas Tilling Limited, and, jointly with the appropriate main line railway companies, controls omnibus services in East Anglia, Bedfordshire, and the West of England. The accounts for 1934 show that the profits were £42,635, against £37,085 in 1933. It is proposed to raise the ordinary dividend from 5 per cent. to 8 per cent., and again to allocate £5,000 to general reserve. During the year, 150,000 ordinary shares were issued, which rank for dividend as from January 1, 1935. The premiums of £56,233 received from this issue have been carried to general reserve.

Scottish Motor Traction Co. Ltd.—Through a clerical error, we stated on page 215 of last week's issue that this company was jointly controlled by the L.M.S.R., L.N.E.R., and Tilling & British Automobile Traction Limited. While, of course, each of these railways has a large shareholding, the remaining shares are in the hands of the public and are not owned by the T.B.A.T. group.

XUM

Railway Share Market

Conditions in the stock and share markets have not been very favourable this week to holders of railway stocks. The natural tendency is for business to be of limited character on the eve of the issue of the annual statements, especially when there is, as at present, considerable doubt as to the actual net revenue obtained and the policy as to dividend distribution to be followed by the respective boards. Dealers in home railway stocks desire to keep their books "even" in case of unexpected surprises.

The first of the statements will appear on Monday in the declaration of the Southern Railway, and in this case market expectations are inclined to look for a very satisfactory announcement. In the belief that the preferred ordinary dividend will be shown to have been nearly, if not wholly, earned, the price of the stock has been maintained at around 80 since commencement of the year. Great Western Railway ordinary stock advanced 3¼ points, and shares with Southern preferred ordinary the prominence of being the only active railway stocks, either home or foreign, which recorded an advance in price at the "Making-Up" on Monday. The demand for the stock came as a result of more confident views about the company's earnings and the expectation that the directors would follow a similar policy to that of previous years in paying 3 per cent. on the stock so as to keep the company's issues within the trustee list. London & North Eastern issues have been on the weak side on doubts as to the first preference dividend.

There has been activity in the 4 per cent. first guaranteed stock, of which a block of £60,417 was placed privately this week; dealings took place at between 100 and 101. In London passenger issues London Transport "C" stock appeared to have grounded at just under 95. A block of Mersey Railway 3 per cent. "B" debenture stock is on offer in the market at about 70 to yield over 4¼ per cent. The company has just declared a dividend of ¾ per cent. on the ordinary stock.

In foreign railways there was relatively little business. Whilst Argentine railway stocks were fairly steady, the market was not strongly tested. Cordoba Central issues were offered on lack of confirmation as to recent rumours of acquisition by the Government, and prices were marked down sharply.

Traffic Table of Overseas and Foreign Railways Publishing Weekly Returns

	Railways	Miles open 1934-35	Week Ending	Traffics for Week: Total this year	Traffics for Week: Inc. or Dec. compared with 1934	No. of Week	Aggregate Traffics to Date: Totals: This Year	Aggregate Traffics to Date: Totals: Last Year	Aggregate Traffics to Date: Increase or Decrease	Shares or Stock	Prices: Highest 1934	Prices: Lowest 1934	Prices: Feb. 6, 1935	Yield % (See Note)
				£	£		£	£	£					
South & Central America.	Antofagasta (Chili) & Bolivia	830	3.2.35	12,670	— 880	5	53,720	60,380	— 6,660	Ord. Stk.	26¾	19	20	Nil
	Argentine North Eastern	753	2.2.35	6,957	— 606	31	226,836	269,506	— 42,670	,,	11	6⅞	7	Nil
	Argentine Transandine ..	111		—	—	—	—	—	—	A. Deb.	52	45	50	8
	Bolivar	174	Jan., 1935	5,850	— 700	4	5,850	6,550	— 700	6 p.c. Db.	10	6½	10	Nil
	Brazil	—		—	—	—	—	—	—	Bonds.	13¾	10⅞16	13	3 15/16
	Buenos Ayres & Pacific	2,806	2.2.35	84,729	— 10,644	31	2,160,603	2,551,204	— 390 601	Ord. Stk.	16½	8½	8½	Nil
	Buenos Ayres Central ..	190	13.1.35	$78 600	— $25 400	28	$3,279,700	$3,216 900	+ $62 800	Mt. Db.	23	10	21½	Nil
	Buenos Ayres Gt. Southern	5,085	2.2.35	208,608	+ 19,219	31	4,066,336	4,916,513	— 850.177	Ord. Stk.	35	22	24	Nil
	Buenos Ayres Western ..	1,930	2.2.35	51,297	— 2,435	31	1,312,038	1,631,925	— 319.887	,,	27½	18½	20	Nil
	Central Argentine ..	3,700	2.2.35	135,024	— 18,255	31	3,623,470	4,249,568	— 626,098	,,	23	13½	14	Nil
	Do.	—	—	—	—	—	—	—	—	Dfd.	14	7	8	Nil
	Cent. Uruguay of M. Video	273	2.2.35	19,133	+ 3,099	31	515.091	505.074	+ 10.017	Ord. Stk.	15½	8	8½	Nil
	Do. Eastern Extn.	311	2.2.35	4,654	+ 956	31	109.134	98.605	+ 10,529	—	—	—	—	—
	Do. Northern Extn.	185	2.2.35	2,429	+ 657	31	58,063	53,699	+ 4,364	—	—	—	—	—
	Do. Western Extn.	211	2.2.35	1,907	— 467	31	46,487	48.965	— 2,478	—	—	—	—	—
	Cordoba Central	1,218	2.2.35	28,360	+ 2,940	31	913.980	1,136,200	— 222.220	Ord. Inc.	6	3	3½	Nil
	Costa Rica	188	Nov., 1934	17.520	— 1,014	17	81.005	99.724	— 18,719	Stk.	30¾	23½	31	6 7/16
	Dorada	70	Dec., 1934	8.100	— 2,900	52	120.900	96.800	+ 24,100	1 Mt. Db.	103	95	102½	5 7/8
	Entre Rios	810	2.2.35	15.130	+ 3,187	31	391,392	414.244	— 22,852	Ord. Stk.	21½	12	13	Nil
	Great Western of Brazil	1,082	2.2.35	13,400	+ 1,700	5	54,400	57,400	— 3,000	Ord. Sh.	⅞	3/8	½	Nil
	International of Cl. Amer.	794	Dec., 1934	$410,865	— $1,049	52	$4,722,779	$4,537,682	+ $185,097	—	—	—	—	—
	Interoceanic of Mexico ..	—	—	—	—	—	—	—	—	1st Pref.	1/-	1/-	1/2	Nil
	La Guaira & Caracas ..	22¾	Jan., 1935	3 100	— 1,300	4	3.100	4.400	— 1,300	Stk.	12¾	7⅝	8½	Nil
	Leopoldina	1,918	2.2.35	25 977	— 193	5	117.593	99 301	+ 18,292	Ord. Stk.	14⅝	7	7½	Nil
	Mexican	483	31.1.35	$330,500	+ $30,400	4	$995,900	$888,800	+ $107,100	,,	3¼	1½	1½	Nil
	Midland of Uruguay ..	319	Dec., 1934	13,508	+ 1,966	26	65.833	57 230	+ 8,603	,,	1½	½	1½	Nil
	Nitrate	401	31.1.35	5,260	— 12,434	4	9 960	133 649	— 23.689	Ord. Sh.	32 9/32	51/-	2¾	Nil
	Paraguay Central ..	274	2.2.35	5.350	+ 2,420	31	145.130	00,820	+ 44,310	Pr. Li. Stk.	84	67	78½	7 5/8
	Peruvian Corporation ..	1,059	Jan., 1935	65,309	+ 6,580	30	436.825	388.420	+ 48,405	Pref.	14½	8	8	Nil
	Salvador	100	2.2.35	¢37,300	+ ¢2,200	31	¢501,252	¢511,433	— ¢10,181	Pr. Li. Db.	75	70	70	7 1/8
	San Paulo	153½	27.1.35	31,125	+ 1,459	4	121,586	115.632	+ 5,954	Ord. Stk.	86	67	67	6
	Taltal	164	Dec., 1934	2.140	— 1,483	26	13.570	12.515	+ 1,055	Ord. Sb.	2⅛	1 7/16	1¾	5 11/16
	United of Havana ..	1,365	2.2.35	30,200	+ 14,450	31	520 966	410.148	+ 110,818	Ord. Stk.	6	2	3	Nil
	Uruguay Northern ..	73	Dec., 1934	1,528	+ 230	26	7,294	7,383	— 89	Deb. Stk.	6¼	3	5½	Nil
Canada.	Canadian National ..	23,733	21.1.35	549,589	+ 12,099	3	1,583,644	1,536,062	+ 47,582	—	—	—	—	—
	Canadian Northern ..	—	—	—	—	—	—	—	—4p.c.	Perp. Dbs.	78¼	51½	74	5 3/8
	Grand Trunk	—	—	—	—	—	—	—	—	4 p.c. Gar.	104½	97¼	101½	3 5/16
	Canadian Pacific ..	17,211	31.1.35	506,000	— 114,400	4	1,653,200	1,794.000	— 140,800	Ord. Stk.	18 5/16	11 1/16	13	Nil
India.†	Assam Bengal	1,329	5.1.35	25.867	+ 2,078	40	1,075,033	939.776	+ 135,257	Ord. Stk.	88½	72	90½	3 5/16
	Barsi Light	202	12.1.35	2,467	— 150	41	110.993	118.830	— 7.837	Ord. Sh.	10 4½	9 8¾	10 4½	5¾
	Bengal & North Western	2,113	12.1.35	50,626	— 197	15	693.345	710,738	— 17,393	Ord. Stk.	297½	262	294½	5 7/16
	Bengal Dooars & Extension	161	12.1.35	3,152	+ 93	41	123 617	123.329	+ 288	,,	125¼	124	126½	5½
	Bengal-Nagpur	3,269	29 12.34	111,375	+ 2,688	39	4,294.172	3,994.722	+ 299.450	,,	105½	96	104½	3 5/16
	Bombay, Baroda & Cl. India	3,072	26.1.35	189.300	+ 19,875	43	6.642.900	6.326,175	+ 316,725	,,	115	108½	114½	5¼
	Madras & South'n Mahratta	3,230	12.1.35	98,775	— 10,286	41	4,340.764	4,401,797	— 61,034	,,	131	122¾	127½	7 7/16
	Rohilkund & Kumaon ..	572	12.1.35	11,539	+ 632	15	137.961	127 864	+ 10.097	,,	263	250	270½	5 15/16
	South India	2,526	5.1.35	70,167	— 3,274	40	3,168,802	3,111,435	+ 57,367	,,	119	115	116	6 7/8
Various.	Beira-Umtali	204	Nov., 1934	64 355	+ 14,678	9	125.490	99,606	+ 25,884	—	—	—	—	—
	Bilbao River & Cantabrian	15	Jan., 1935	2,249	+ 702	4	2.249	1,547	+ 702	—	—	—	—	—
	Egyptian Delta	621	20.1.35	7.556	+ 684	42	195,043	191,068	+ 3,975	Prf. Sh.	21 3/16	15¼	23⅜	4 1/4
	Great Southern of Spain	104	26.1.35	1,951	— 243	4	8,699	9.516	— 817	Inc. Deb.	4	3½	3½	Nil
	Kenya & Uganda ..	1,625	Dec., 1934	196,966	+ 41,493	52	2,227,178	2,088,162	+ 139,016	—	—	—	—	—
	Manila	—	—	—	—	—	—	—	—	B. Deb.	50	33	48	7 5/16
	Mashonaland	913	Nov., 1934	115,238	+ 23,474	9	232.511	186,337	+ 46.174	1 Mg. Db.	101	91¾	102½	4 7/8
	Midland of W. Australia	277	Dec., 1934	14,518	— 767	26	85.947	80.396	+ 5.551	Inc. Deb.	100	93	96½	5 5/16
	Nigerian	1,905	15.12.34	63,801	+ 10	37	1,286.098	1,072,876	+ 213,222	—	—	—	—	—
	Rhodesia	1,538	Nov., 1934	185,477	+ 29.280	9	375,036	316,298	+ 58 738	4 p.c. Db.	104 7/8	97½	105	3 15/16
	South African	13,217	12.1.35	538,463	+ 67,486	41	21,070,058	18 557.986	+2,512 072	—	—	—	—	—
	Victorian	6,172	Oct., 1934	893,146	+ 75,686	17	3,032.823	2,938,131	+ 94,692	—	—	—	—	—
	Zafra & Huelva	112	Dec., 1934	10,586	— 141	52	138,474	134,554	+ 3,920	—	—	—	—	—

NOTE.—Yields are based on the approximate current prices and are within a fraction of 1/16.

† Receipts are calculated @ 1s. 6d. to the rupee. § ex dividend. Salvador receipts are in currency.

The variation in Sterling value of the Argentine paper peso has lately been so great that the method of converting the sterling weekly receipts at the par rate of exchange has proved misleading, the amount being overestimated. The statements from July 1 onwards are based on the current rate of exchange and not on the par value

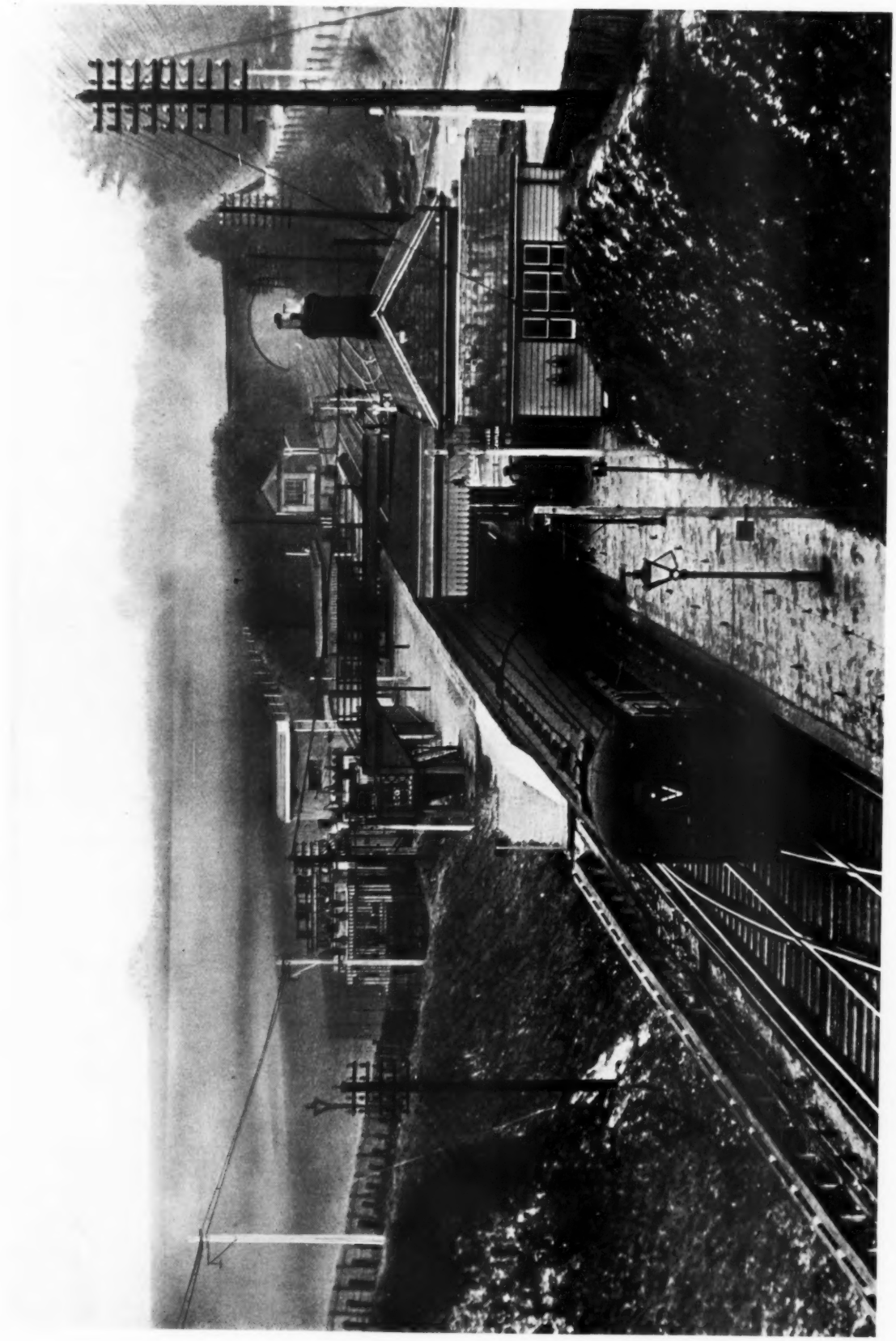
Electric Railway Traction

The Sevenoaks Electrification, Southern Railway

ALMOST 66 years after it first appeared in railway timetables, upon the completion of the South Eastern Railway's direct line to Tonbridge, Sevenoaks has been given the benefit of an electric service, and, to the popular mind at least, has been reduced in status from a well-known country town, with 25-35 trains a day according to the season, to an offshoot of suburbia, with 110 trains a day in each direction. The conversion of the two routes to Sevenoaks was decided upon in 1933, and formed the lesser portion of the Southern Railway's great extension programme covering the electrification of 83 route and 168 track miles at a cost of approximately £2,250,000; the remainder of the programme covers the Eastbourne and Hastings lines. A sum of £500,000 has been spent in the conversion of the 23 route and 50 track miles of the Sevenoaks lines, and the first portion of this, the short section from Bickley to St. Mary Cray, was opened to electric traction on May 1, 1934. The extension on through Swanley and Otford, and the conversion of the main line from the previous electric terminus at Orpington, was opened to regular traffic on January 6.

The decision to undertake the conversion of the Sevenoaks routes may be taken as a vote of confidence in the performance and possibilities of electric operation in promoting increased traffic, while at the same time effecting a reduction in operating cost compared with that for steam traction under comparable conditions. It is not too much to say that the traffic now circulating on the Eastern Section suburban lines of the Southern Railway could not be worked by steam traction, but it is equally true to say that, if steam haulage had remained, the traffic would not have attained anything like its present proportions. Quite apart from those extraordinary traffic increase figures which Sir Herbert Walker is prone to spring upon the doubting Thomases, the vast development of the south-eastern area of Greater London in the past five years forms a striking commentary on the preference of the community for a fast, frequent and clean service at fares similar to those charged on lines which ought to be electrified but are not. There is in certain quarters a doubt whether the cost of electrifying a network of lines is not too great for a reasonable return to be obtained, but there do not appear to be any grounds for supposing that the Southern Railway, with its extensive experience of the greatest suburban electrification in the world, has taken a risk in sinking half-a-million pounds on the Sevenoaks extensions. Moreover, the success of the previous Southern electrification extensions proves the possibilities of such works in gaining traffic with a relatively small increase in operating costs. The extra trains (giving an increase for certain stations of 200 per cent.) down the main and Swanley lines have necessitated the provision of only 11 extra three-coach train sets and 4 two-coach trailer sets, so that an increase of 6½ per cent. in the route mileage has necessitated an increase of only 2 per cent. in the rolling stock. The same applies to the generating and distributing plant.

Reproduction of one of the Southern Railway's coloured posters announcing the opening of the Sevenoaks and Eastbourne lines



A THREE-CAR TRAIN FROM SEVENOAKS TO CHARING CROSS IN CHELSFIELD STATION

ELECTRIFICATION of the SEVENOAKS LINES

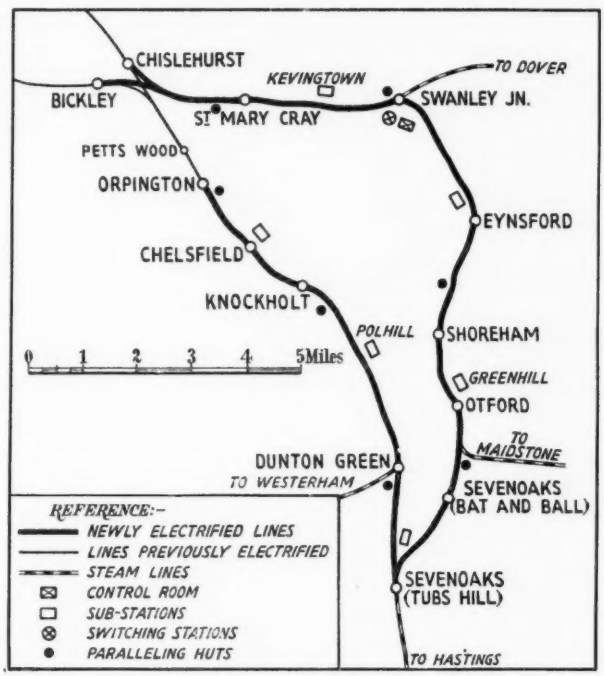
Important extension of the Southern Railway electrified London suburban lines in the Eastern Section

AN important step towards the complete electrification of the ever-widening London suburban area of the Southern Railway has been made by the inauguration of electric services over the lines from Bickley to Sevenoaks via Swanley and from Orpington to Sevenoaks down the main line, a combined route mileage of 23 and a track mileage of about 50. The short section from Bickley to St. Mary Cray has been operated electrically since May 1, 1934.

The equipment of the Sevenoaks lines follows the practice of the Brighton line as regards feeder and substation equipment, and keeps to the designs found on the suburban routes for rolling stock. As with all the recent electric extensions of the Southern, the conversion scheme was prepared and carried out under the direction of Mr. Alfred Raworth, the company's Electrical Engineer for New Works, by whose courtesy we recently inspected the line and its working. The rolling stock, apart from the electrical equipment which has been Mr. Raworth's responsibility, has been produced by Mr. R. E. L. Maunsell, C.B.E., Chief Mechanical Engineer, and all the civil engineering works undertaken in connection with the electrification have been carried out under the jurisdiction of Mr. George Ellson, O.B.E., Chief Engineer.

Power Supply and Distribution

The energy supply is obtained from two points on Central Electricity Board's grid, one via the main transforming station at Northfleet and the other via the main transforming station at Tunbridge Wells. Between each



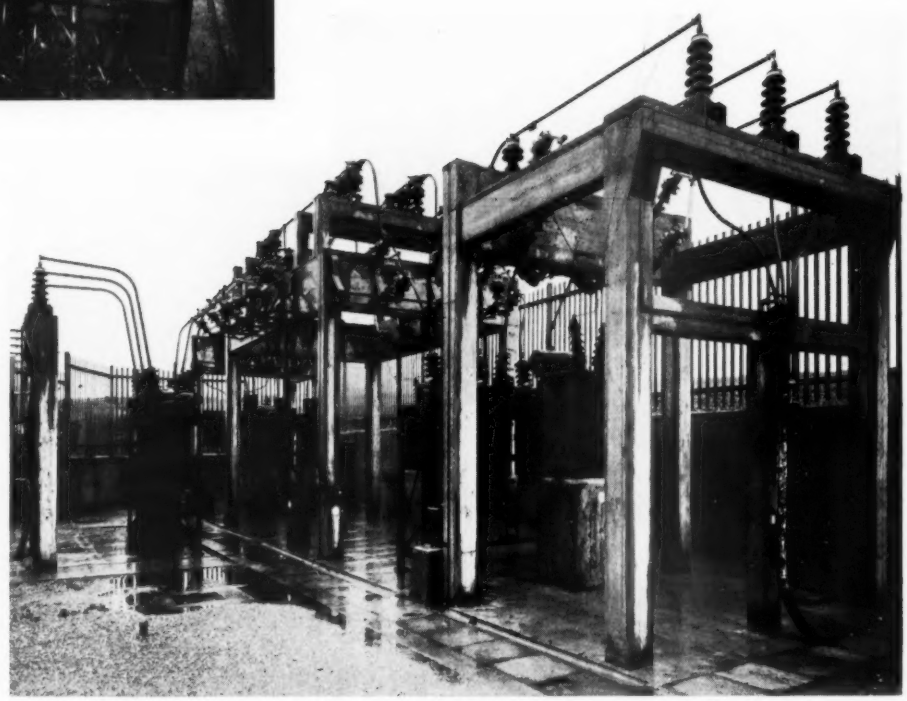
Map of Sevenoaks electrified lines

Junction of the main line with the Swanley branch at Sevenoaks, looking south

Above : 33 kV. switchgear at Swanley switching station. One of the track paralleling huts can be seen adjacent to the signal box on the down side

is provided by hand-operated switches on a cubicle situated in a small building adjacent to the oil switches. The necessary feeder protection relays are also mounted on this cubicle. A 30 kVA. auxiliary three-phase transformer, mounted on a concrete block, provides a 440-volt a.c. supply for heating and lighting in the control room and for the local lighting and other auxiliaries at the switching station.

The 33 kV. supply is fed to six remotely-controlled mercury arc rectifier substations where it is converted to 660 volts d.c. for distribution to the conductor rails. Each substation is fitted with a Bruce Peebles (Brown Boveri type) mercury arc rectifier with attendant transformer, switchgear, and auxiliary apparatus; all the substations are identical as regards equipment, and almost so in the matter of layout. The incoming 33 kV. feeders, isolators and circuit breakers are mounted on a concrete framing similar to that used on the Brighton section. A single-phase transformer of 20 kVA. capacity is connected direct to each of the incoming 33 kV. feeders for providing the energy for signalling, lighting and other auxiliary purposes. From the short bus section between the two e.h.t.



Right : 33 kV. outdoor switchgear and auxiliary transformers at Chelsfield substation

Bottom : High-speed d.c. switchgear in one of the paralleling huts which are located approximately mid-way between the substations

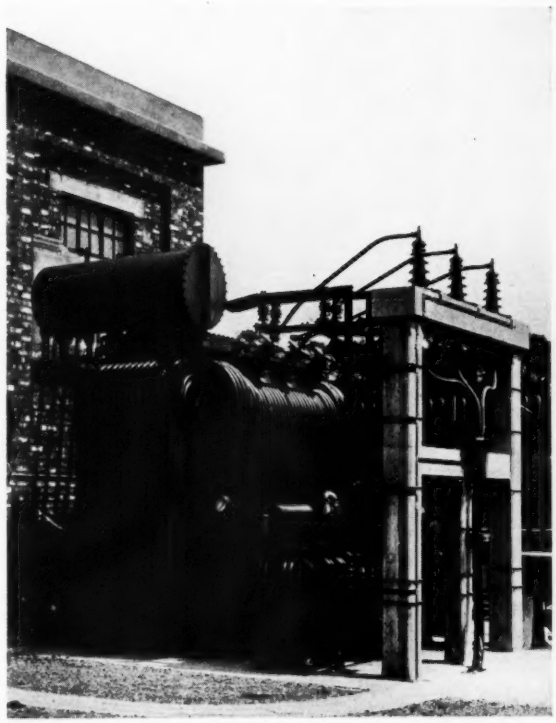
of these two points, from which energy is supplied at 33 kV. 50 cycles, a high-tension cable is laid looping in en route the railway company's substations as shown by the accompanying diagram. An outdoor switching station at Swanley provides a tee off the main e.h.t. distribution cable for the two substations which are not on the main cable route. The incoming and outgoing e.h.t. feeder equipments at Swanley switching station are supported on concrete framework similar in design to that used for the e.h.t. switchgear in the substations, each set of equipment consisting of an oil switch and its associated isolators. Each of these oil switches, as well as those installed at the substations, has a rupturing capacity of 500,000 kVA. The switching station is controlled from the central control room at Swanley, but local operation

feeders a tee-off is taken through an oil switch to supply an oil-cooled transformer, situated in the open, which converts the three-phase 33 kV. supply into a double six-phase supply at the voltage required for the anodes of the rectifier.

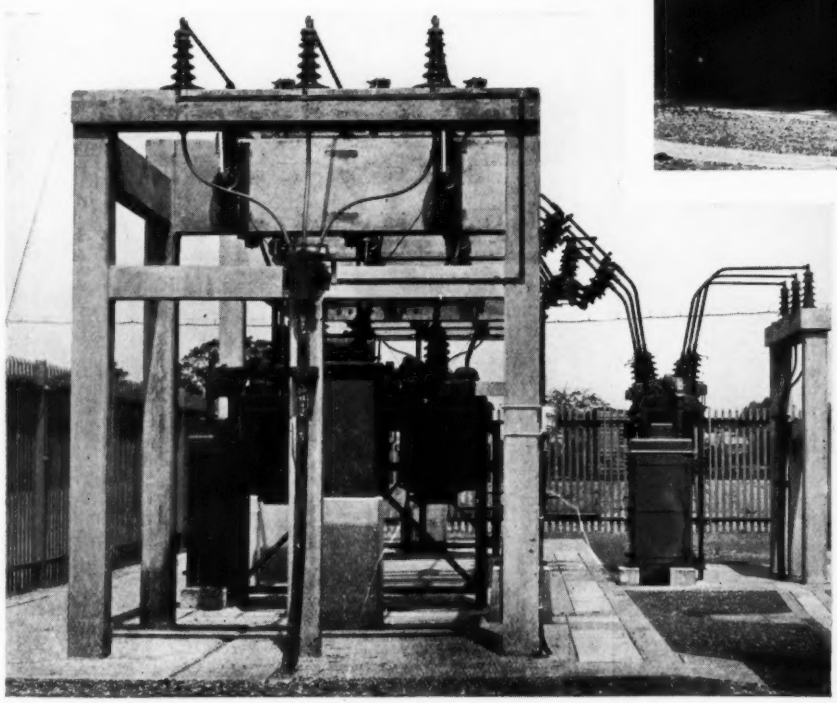
A tee-off connection is also made to a 30 kVA. three-phase transformer providing energy at 440 volts for the rectifier auxiliaries. Two small units are adjacent to the main transformer, forming the absorption choke coils, and between them is a smaller unit for their excitation.

The metal-clad rectifiers are duplicates of those installed in the 18 substations on the Brighton and Worthing extension. The continuous rating is 2,500 kW., equivalent to a current of 3,790 amp. on the d.c. side; higher currents can be produced for shorter times, up to a momentary maximum of over 12,000 amp. Cooling of the rectifier is effected by a closed water circuit through a radiator over which air is drawn by a fan which is thermostatically controlled. A compact cubicle faced by a flush-type switchboard is provided for housing the local equipment for the operation of the e.h.t. switchgear and the rectifier with its auxiliaries. The switchboard is divided into three panels arranged for the control of the e.h.t. switchgear, rectifier, and auxiliary services respectively, and provides for the definite indication of any possible fault which could occur.

On the d.c. side of the rectifier is a main high-speed circuit breaker of a continuous carrying capacity of 4,000 amp. situated in the positive lead from the rectifier, and four smaller circuit breakers, one for each of the four track feeders. The main high speed circuit breaker is arranged to trip on reverse current, whereas the track-feeder circuit breakers trip on forward current. Isolators are provided on all the circuit breakers so that they can be completely isolated when occasion demands without disturbing the supply to the remaining circuit breakers. The return current is carried to the negative busbar by means of feeder cables connected to the running rails.



Above : Oil-cooled transformer located outside the substation building



Left : 33 kV. switchgear and isolators for the ring main and the tee-off to the rectifier at one of the Southern Railway substations

Bottom : Cable lead to conductor rail through standard hook switch

The negative busbar is in turn connected to the transformer neutral via the two absorption choke coils.

The conductor rails are of the Southern Railway's standard type; they are of B.S. flat-bottomed section with a weight of 100 lb. a yard, and are mounted on

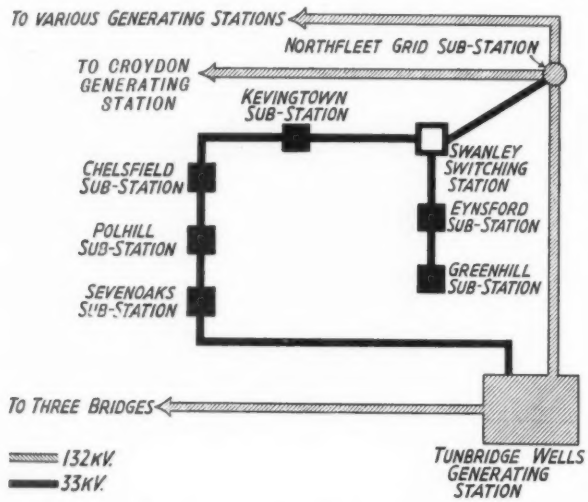
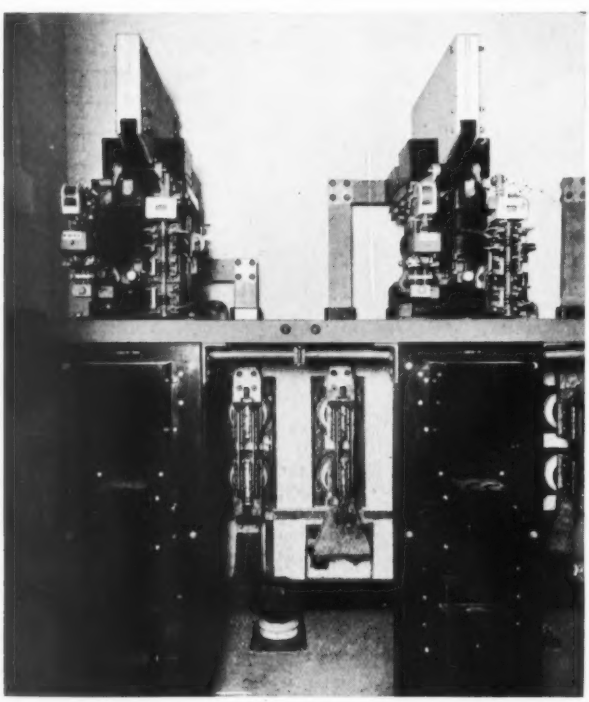


Diagram showing power supply to Sevenoaks lines, Southern Railway

porcelain insulators. They are bonded together by means of four copper bonds having an aggregate cross section of 1·68 sq. in. The negative traction circuit is returned through the running rails, which have protected bonds consisting of flat copper strips between the web of the rail and the fishplate; the two bonds per rail joint have a cross section of 0·332 sq. in. The bonds at points and crossings, and the cross-bonds between the running rails, are of the stranded type. Hook switches are provided between the feeder cables and the conductor rails at certain points for the purpose of isolating sections of the electrified track. Midway between each pair of substations the sections are paralleled through automatic high-speed circuit breakers located in huts at the side of the line.



High-speed d.c. circuit breakers with control panels and isolators

Supervisory Remote Control

The whole of the electrical equipment in the substations and switching station is arranged for the remote operation by supervisory control from a central control room at Swanley. The positions of the switchgear in the track paralleling huts are also indicated in the control room. As at Three Bridges, on the Brighton section, the control room is D-shaped in plan, but the panels for the existing equipment extend only over a portion of the curved wall, leaving plenty of room for future extensions. The control

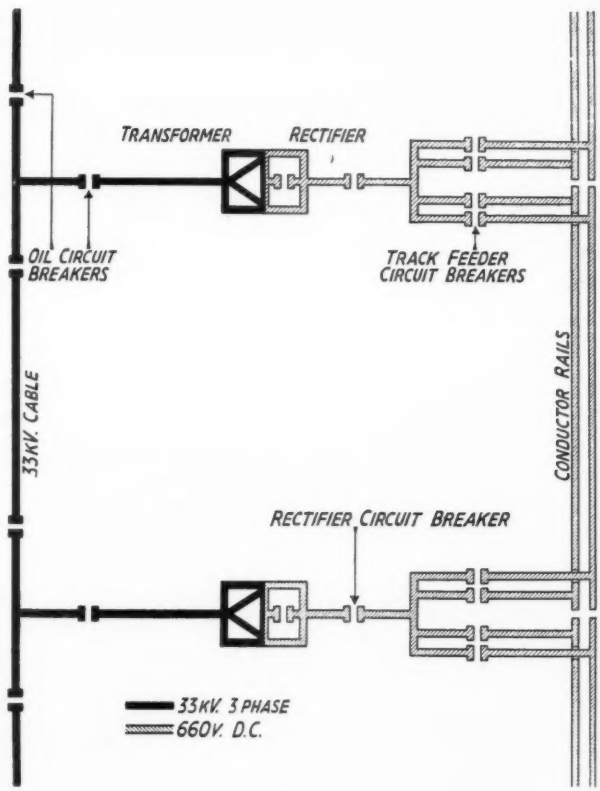
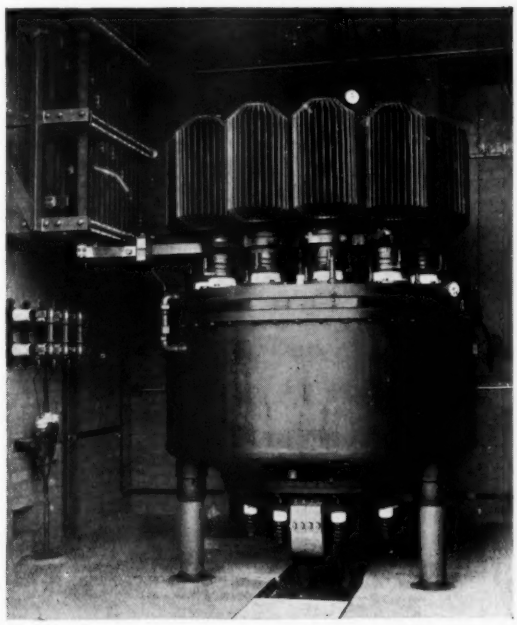


Diagram of principal connections in remotely-controlled substation on Sevenoaks line

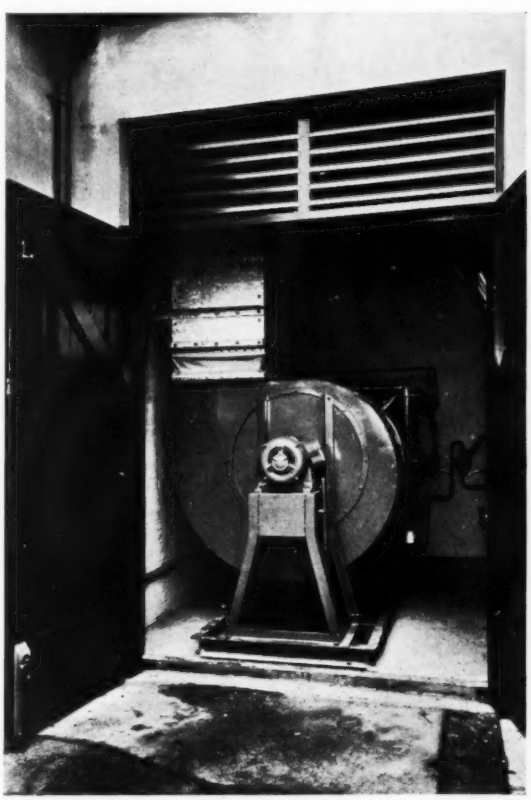
room has no windows and is illuminated indirectly from a single central standard light. Forced ventilation is provided, and the incoming air is heated by resistors, controlled thermostatically so as to maintain an equable temperature in one or other of three stages. The desk in the centre of the floor accommodates a private telephone exchange to all the substations, and track paralleling huts, together with a fault indicating system for each of these points and a set of calling keys and instruments for the testing of the supervisory pilot system.

Plug points for a portable telephone are provided on all the panels and inside the cubicles so that telephonic communication can be made between any points in this system. At the appropriate points in the diagram on the

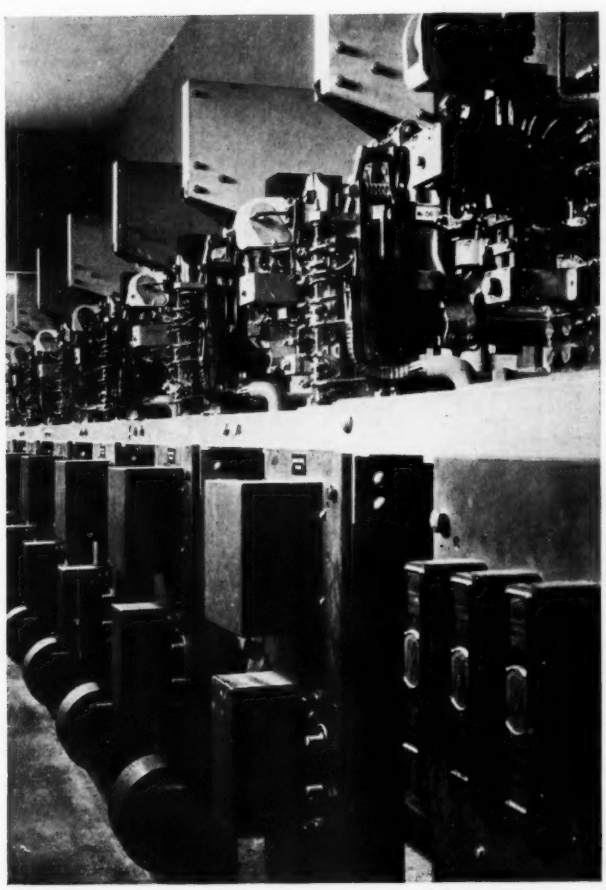
Delta double-Z connection transformer supplying a 2,500 kW. mercury arc rectifier. The negative busbar equipment is in the foreground



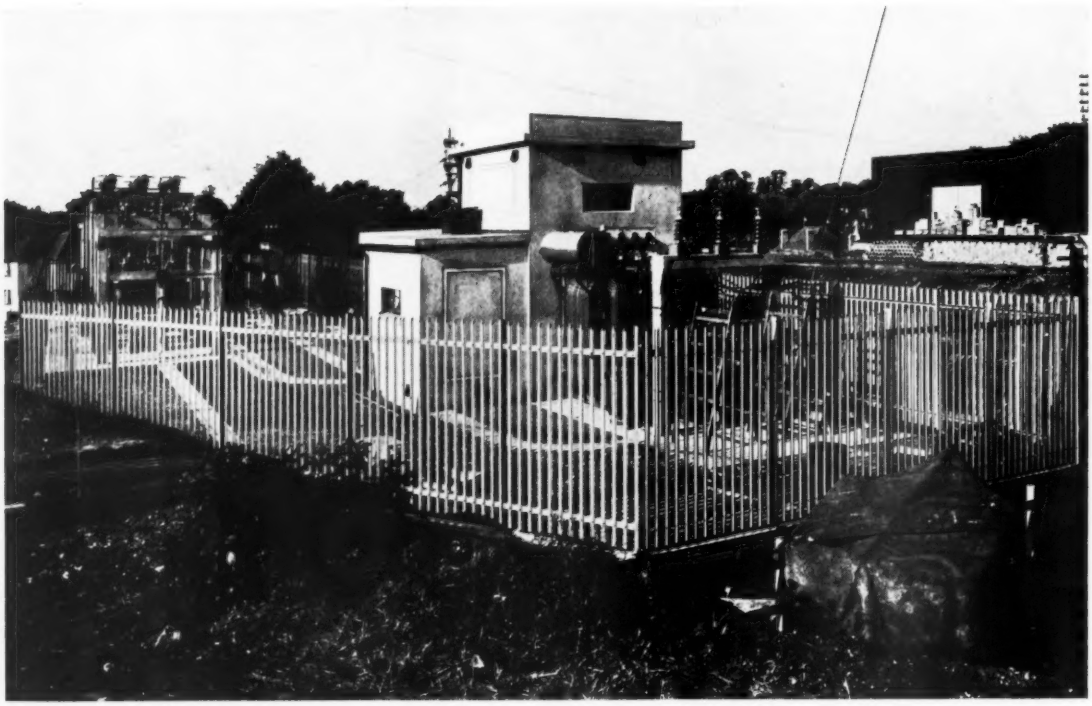
2,500 kW. Bruce Peebles mercury-arc rectifier as used by the Southern Railway



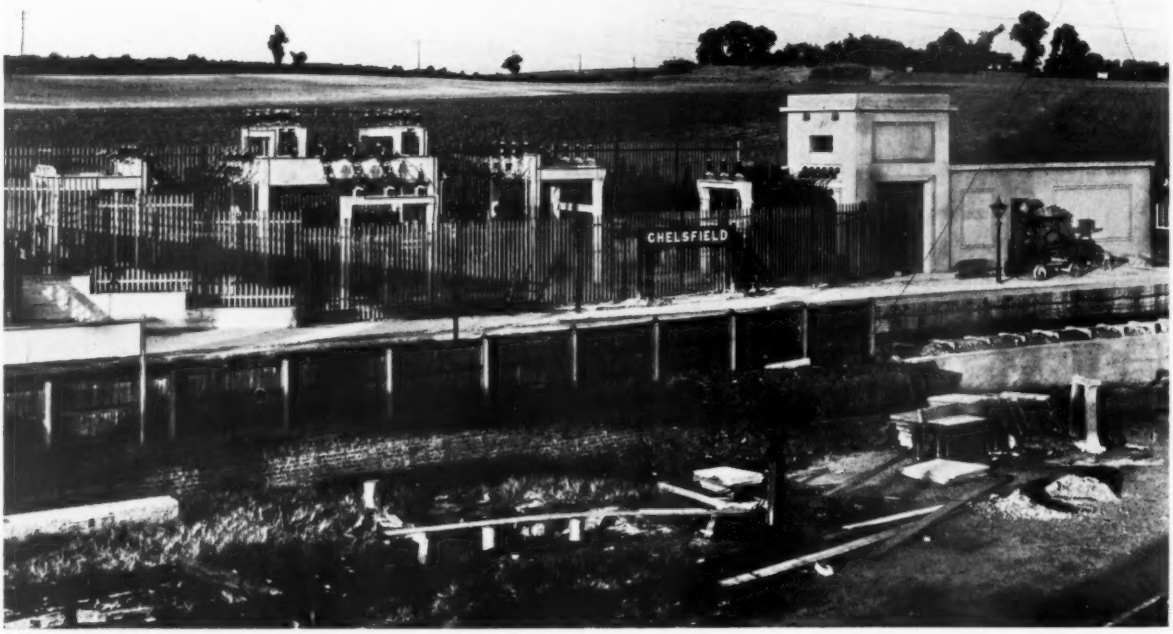
Motor-driven recooler for rectifier as used in the substations of the Sevenoaks lines



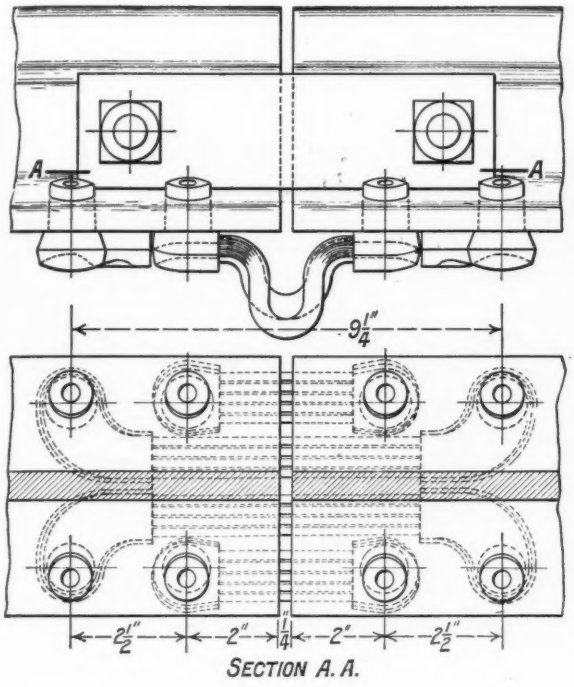
High-speed circuit breakers controlling the 660-volt d.c. track feeders at one of the substations

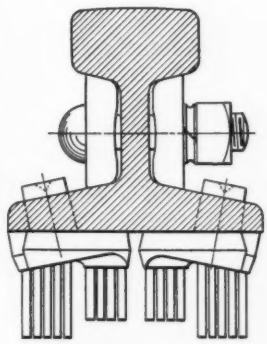


Sevenoaks substation is located at the junction of the main Dover line and the Swanley branch



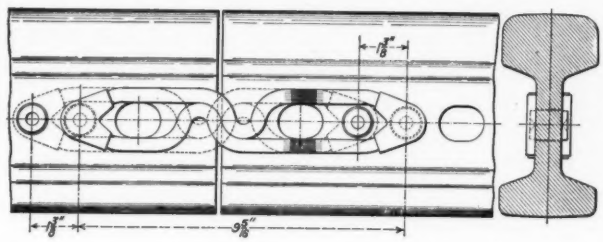
The substation at Chelsfield is immediately behind the passenger station, the platforms of which have been lengthened

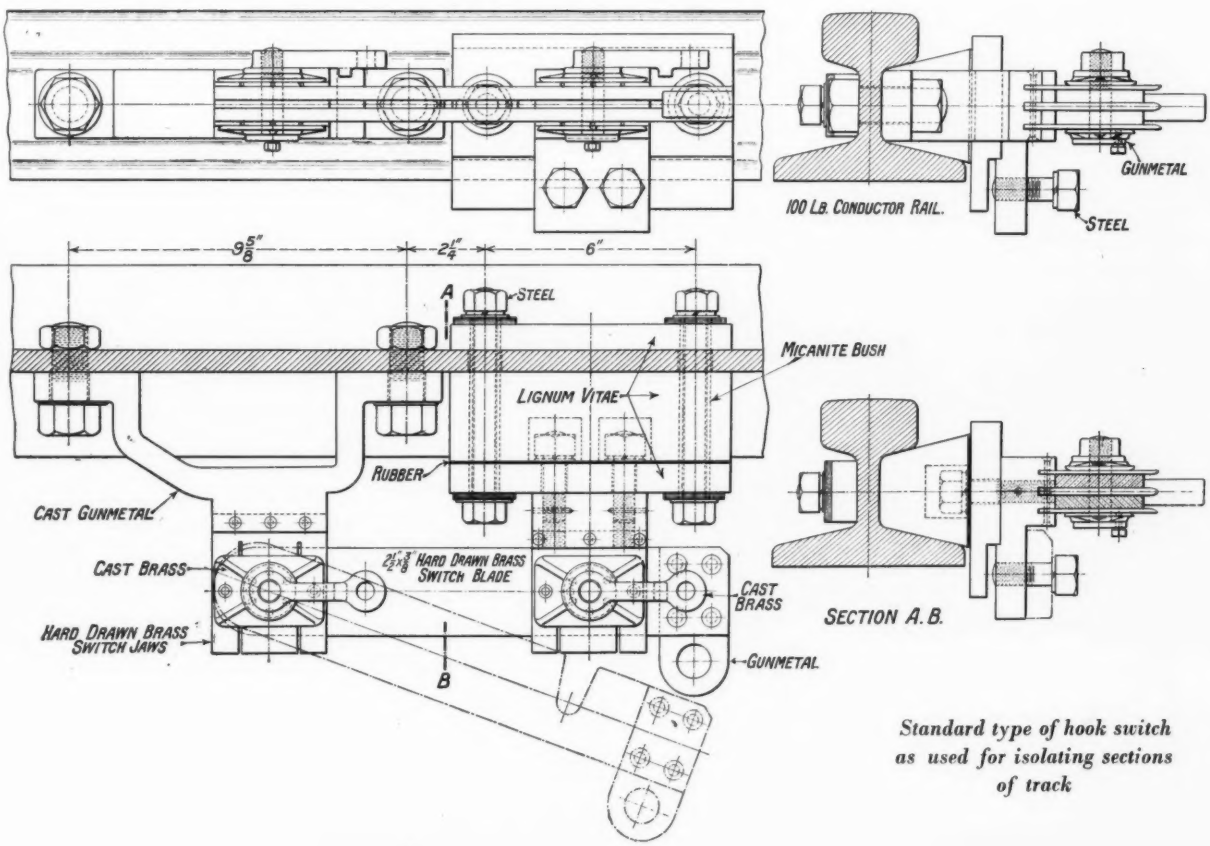




Left: Method of bonding the standard 100 lb. per yd. conductor rails on the Southern Railway

Below: Bonding of the running rails. When the track is laid, the bonds are covered by the fishplates





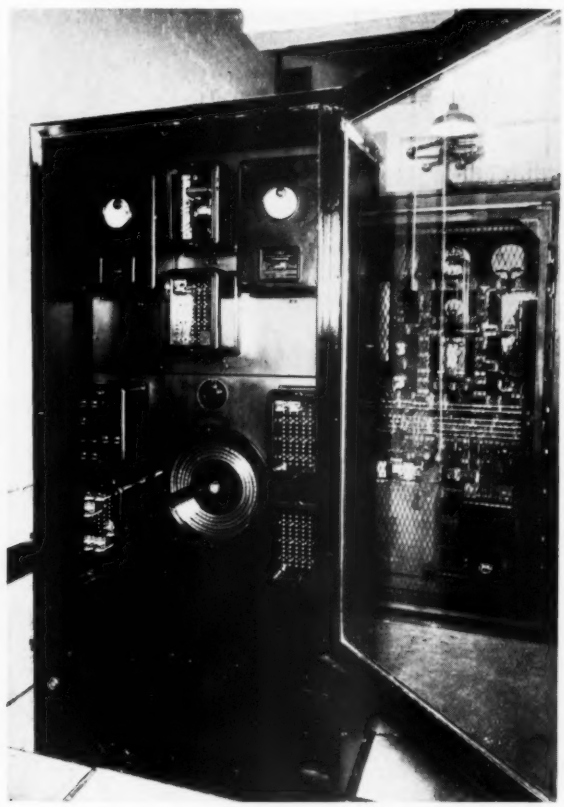
Standard type of hook switch as used for isolating sections of track

control board there are two operating keys and three signal lamps—green, red and white—for each main high-tension oil switch or d.c. high-speed circuit-breaker. These keys control circuits to the actual oil-switch or d.c. circuit-breaker operating mechanisms, fed through 5-core pilot cables from a special d.c. 120-volt system. To operate an oil switch or d.c. circuit-breaker in a distant substation the procedure is as follows. The calling-key on the control board for the switch in question is first depressed. This action releases the rotating arm of a selector switch mechanism in a transmitter cubicle behind the control board, and simultaneously a similar selector switch in the distant substation also commences to rotate in synchronism. When both the switches arrive at contacts corresponding to the calling-key they stop, and a white signal lamp is lit on the control board to indicate that this part of the process has been correctly performed. The circuits to the operating contactor have now been prepared, and the actual closing or opening of the distant switch is achieved by using the second key on the control board. Pushing this downwards closes the distant switch, and upwards opens it. When the switch has actually performed the operation required it lights a red or green signal lamp at the control board, according to whether it is then closed or open. Thus the attendant can observe the operation of the remotely-controlled equipment. All that is necessary to put a substation into commission is to close the oil switches and high-speed circuit-breakers in this way. Other auxiliary gear at the substations comes into use automatically and is so interlocked that it prevents remote operation of the substation if conditions are not satisfactory. All the supervisory apparatus is of the plug-in type, so that if necessary any unit can be removed bodily and a spare substituted without interfering with wiring or connections. If at any time a selector switch falls out of step with its corresponding switch a correcting device comes into operation automatically to restore synchronism.

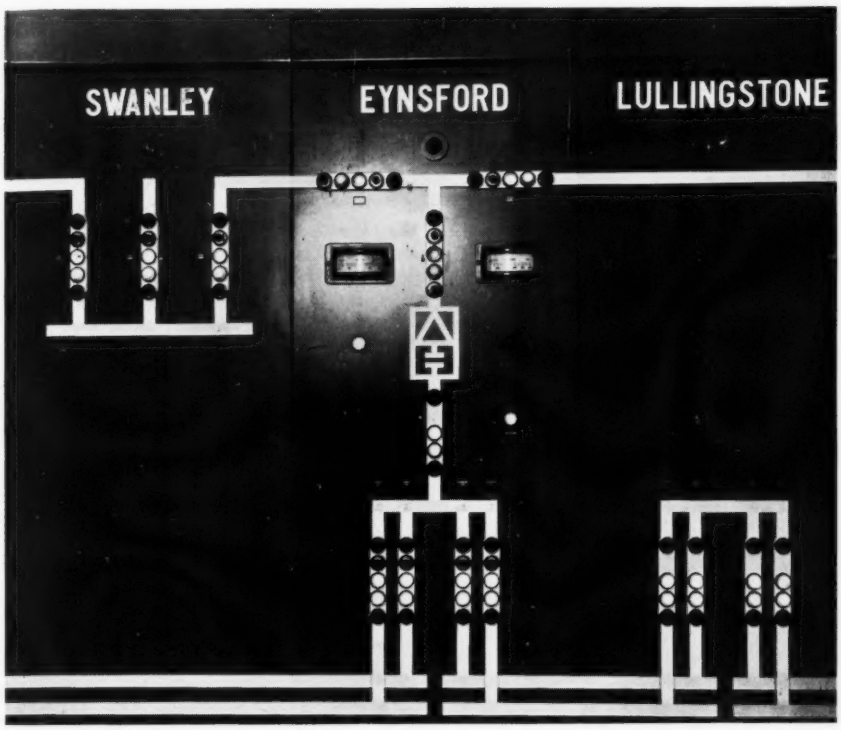
Both the oil switches and high-speed circuit-breakers are fully provided with protective gear. When one of them operates automatically due to a fault, the fact is signalled to the control room by the dropping of a shutter and the ringing of a bell, while a fault lamp on the panel affected commences to flicker. These conditions persist until the attendant actuates a reset key. The attendant then proceeds to discover which switch has operated, by depressing a check key. Thereupon the selector switches rotate together and check all the indications of the signal lamps on the board. As the switches pass over the contacts corresponding to the switch which has automatically tripped, the signal lamps on the control unit of this switch change from red to green. Further important information is obtainable at any time by the control room attendant by the use of a meters key. This gives, via the selector switches and a balanced-beam potentiometer relay equipment, readings on instruments on each panel showing the volts and amperes at the distant substation. Another protective device is a feeder synchronising indicator, which consists of an orange signal lamp that glows steadily when synchronism is indicated.

The lamp signals and relay operating currents are derived from duplicate centre-tapped 120-volt 250 amp.hr.

Remote-control selector apparatus in transmitter cubicle at Swanley control station

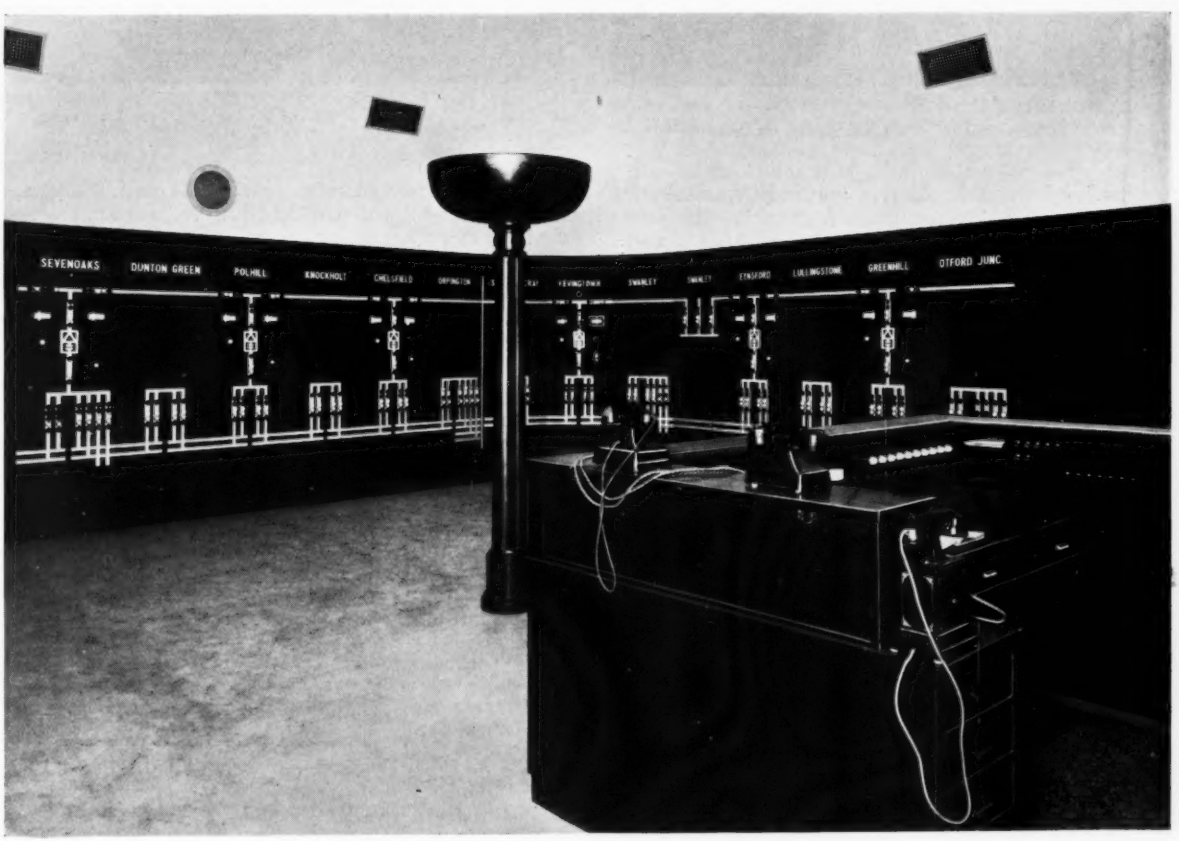


Remote-control selector apparatus in receiver cabinet at substation



Left: Three typical panels of the control board at Swanley. Left to right are shown: panel for Swanley switching station; panel for Eynsford rectifier sub-station; panel for Lullingstone paralleling hut

Below: General view of the interior of the control room, showing the panels for the six substations, seven paralleling huts, and Swanley switching station



TWO VIEWS OF INTERIOR OF CONTROL ROOM AT SWANLEY

accumulators at the control room, and the check signals emanate from similar batteries of 50 amp.hr. capacity at each substation. The latter batteries are charged through metal rectifiers and are normally left on trickle charge. An indication of the voltage of the batteries in the substations can be obtained at the control room by means of special keys and instruments arranged on the central desk, so that conditions in this respect can be readily checked. The batteries at the control room are charged through automatically operated motor-generators, one of which is driven by a.c. and the other by d.c. taken from the local track. The whole of the e.h.t. switchgear and the supervisory equipment has been supplied by Asea Electric Limited, of London.

Services and Rolling Stock

As the normal suburban services on the Eastern Section are extended beyond St. Mary Cray and Orpington, the previous termini of electric traction in this area, extra stock has been found necessary, and the Lancing works of the Southern Railway has converted old steam-hauled stock into 11 three-coach trains and four two-coach trailer sets of the standard suburban type. The underframes and bogies of these vehicles are new, and the bodies converted from those of old first class and third class non-corridor stock; in the case of the motor-coaches the luggage and driving compartments have been built on to the old bodies. As a general rule, eight-car trains will be worked in the rush hours to Orpington and Swanley, and a three-car set on from there to Sevenoaks. During the day a three-car set is the normal formation, and is simply continued on to Sevenoaks.

The trains down the main line give approximately a half-hourly service, with additional trains (including some steam-worked) at rush hours. A feature is the new fast trains running from London Bridge non-stop to Petts Wood in 15 to 18 min. (10¾ miles) and to Orpington in 17 to 21 min. (12 miles). In the reverse direction, both Knockholt and Chelsfield are used as starting points for electric trains during the morning business hours. The service on the Westerham branch has been greatly improved, and now consists of 22 down and 21 up trains.

On the Swanley route, the 20-min. service from St. Paul's, via Nunhead, which since May 1, 1934, has terminated at St. Mary Cray, has been extended through Otford and Eynsford, and 52 down and 47 up trains are run on weekdays. There is a gap of one hour, from 8.37 a.m. to 9.37 a.m., in the down direction between Swanley and Sevenoaks for through trains, but, by a change at Otford, Swanley can be left at 9.17 and Sevenoaks reached at 9.42 by steam trains.

A three-car set weighs 110 tons and has a seating capacity of 56 first class and 170 third class; the two-car trailer units scale 54 tons and seat 200 third class passengers. The total capacity of an eight-car set is thus 112 first class and 540 third class seats in an overall length of 515 ft. 4 in.; the three-car sets have a length of 193 ft. The general design of the coaches is similar to that of the existing stock, and the trains are braked by compressed air with Westinghouse equipment. Each three-car set is driven by four standard 275 h.p. nose-suspended traction motors built by the English Electric Co. Ltd., and the control equipment has been built by the Metropolitan-Vickers Electrical Co. Ltd. The motors are designed for a free running speed of 54 m.p.h. and are among the largest self-ventilated low voltage d.c. traction motors in existence.

Sevenoaks (Bat and Ball) station

Three-car train in Swanley Junction station

Contractors

The following contractors, manufacturing engineers, and other firms were employed on work in connection with the extension of electrification to Sevenoaks:—

Asea Electric Limited (London)	33 kV. switchgear, L.T. transformers, and supervisory equipment.
British Insulated Cables Limited	Rail bonds.
British Thomson-Houston Co. Ltd.	High speed circuit breakers.
Bruce Peebles & Co. Ltd.	Rectifier equipments.
Chamberlain & Hookham Limited	Meters.
Chloride Electrical Storage Co. Ltd.	Batteries.
Doulton & Co. Ltd.	Rail insulators.
Edmundson's Electricity Corporation Limited	Lighting and power installations.
English Electric Co. Ltd.	Traction motors.
Estler Bros. Limited	Track switches.
Macintosh Cable Co. Ltd.	Low tension cables.
Metropolitan-Vickers Electrical Co. Ltd.	Train control equipments.
Parmiter, Hope & Sugden Limited	Auxiliary a.c. apparatus.
Pirelli-General Cable Works Limited	33 kV. and pilot cables.
Rosser & Russell Limited	Heating and ventilating equipment at Swanley control station.
Taylor, Tunnicliff & Co. Ltd.	Rail insulators.
Westinghouse Brake & Saxby Signal Co. Ltd.	Rectifiers for the remote control apparatus, and rolling stock brakes.